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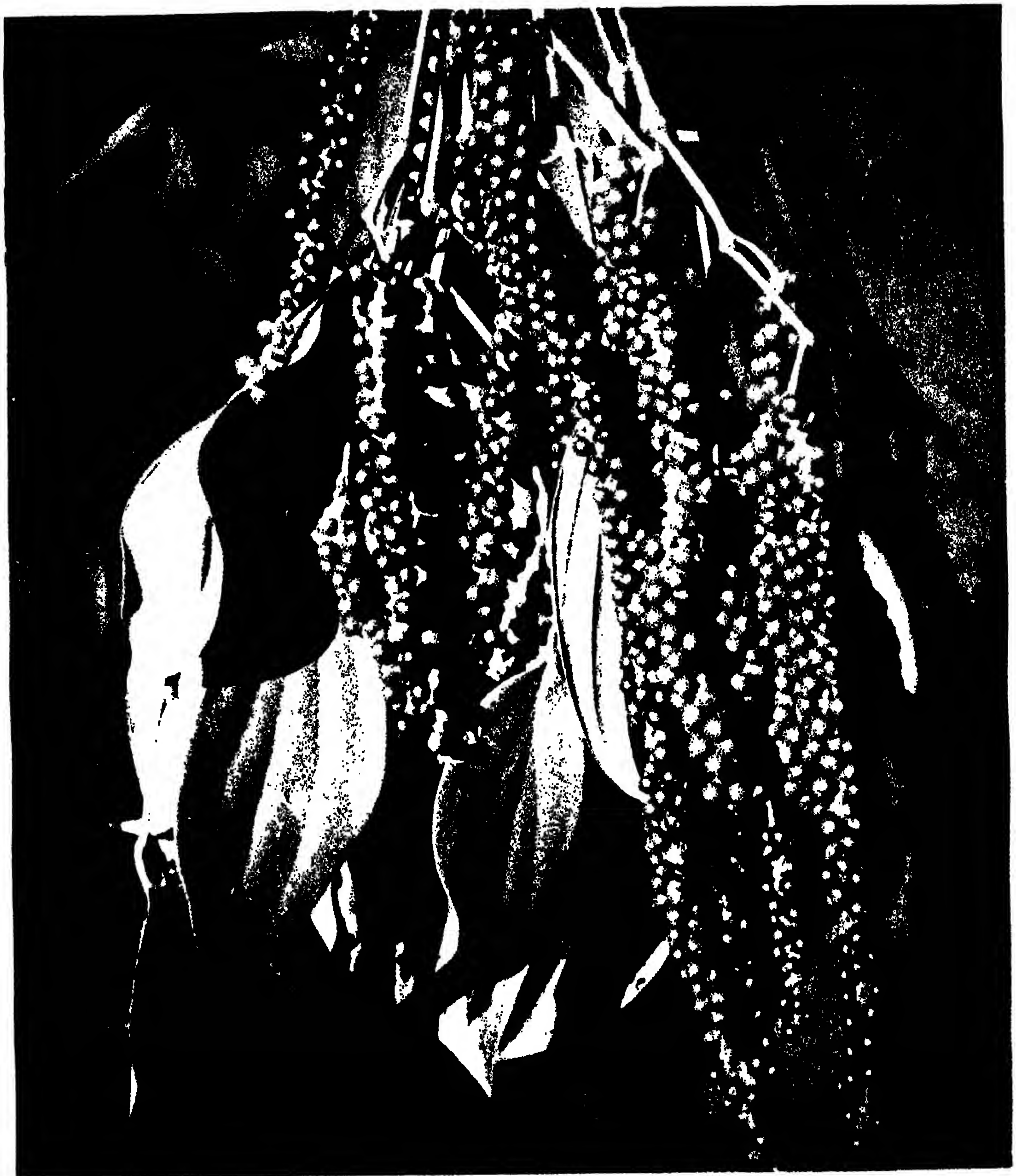
THE
WEALTH OF INDIA

Pl. I



I.C.A.R., New Delhi

PIPER NIGRUM—FRUITING BRANCH

THE
WEALTH OF INDIA

A DICTIONARY OF
INDIAN RAW MATERIALS
AND INDUSTRIAL PRODUCTS

RAW MATERIALS
VOL. VIII : Ph—Re

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INTRODUCTION

This volume, the eighth in the Raw Materials series, covers the alphabetical sequence Ph–Re and contains a large number of entries—plant species, 457; animals and animal products, 5; and minerals, 5. Some of the important topics covered are: *Phaseolus, Phoenix, Pinus, Piper, Pisum, Plantago, Podophyllum, Polygonum, Pongamia, Populus, Prunus, Psidium, Pterocarpus, Pueraria, Punica, Pyrus, Quercus, Raphanus* and *Rauvolfia* among plants; *Porpoises & Dolphins*, and *Prawns, Shrimps & Lobsters* among animals; and *Phosphates, Quartz* and *Rare Earths* among minerals.

The compilation of articles on some of these topics presented problems, particularly those on genera like *Phaseolus, Piper, Prunus* and *Pyrus*. Considerable amount of correspondence and literature search had to be undertaken on *Phaseolus* to decide upon the taxonomic position of the Indian species, which, according to modern taxonomic concepts, are included under *Vigna*. In the case of the genus *Piper*, absence of any taxonomic work on the Indian species posed the problem of assigning some of their products to their exact source plant, particularly the several types of long pepper. Similarly, the position of the Indian species of *Prunus* and *Pyrus* required careful evaluation. In the case of *Pimpinella* (aniseed), considerable confusion exists in trade as well as in literature regarding the correct identity of the source plant of the Indian aniseed. Examination of market samples revealed that three different plants were involved. On some of the cultivated crops like *Phaseolus, Pisum, Plantago, Piper betle* and *Prunus*, no comprehensive published information was available regarding the extent of their production in India and had to be supplemented by correspondence with the authorities concerned and visits to cultivating areas and institutions specializing on them. On various medicinal plants, particularly those on *Plumbago, Podophyllum, Polygala, Psoralea* and *Rauvolfia*, the enormous amount of information regarding the chemical constituents and principles had to be carefully evaluated and presented concisely. Every effort has been made to give all the available information and bring it up-to-date.

As in the case of the earlier volumes, assistance in the form of contributed articles has been received from some outside specialists (mentioned in parenthesis). These articles have been utilized in preparing the following entries: *Phoenix dactylifera* (Shri Daljit Singh, Indian Council of Agricultural Research, New Delhi); *Pinus* and *Pterocarpus* (Shri P. Venkataramani, Forest Research Institute, Dehra Dun); *Piper nigrum* (Shri Fazlullah Khan, Department of Agriculture, Madras); *Pogostemon cablin* (Dr. M. C. Chaco, Indian Institute of Science, Bangalore); *Pongamia* (Dr. J. S. Aggarwal, Regional Research Laboratory, Hyderabad); *Psidium* and *Punica* (Dr. L. B. Singh, National Botanic Gardens, Lucknow); *Pistacia, Plantago* and *Psoralea* (Central Drug Research Institute, Lucknow); *Porpoises & Dolphins* (Dr. E. G. Silas, Central Marine Fisheries Research Institute, Mandapam); *Prawns, Shrimps & Lobsters* (Shri M. Krishna Menon, Central Marine Fisheries Research Institute, Mandapam); *Phosphates* (Dr. M. S. Krishnan, Hyderabad); *Quartz & Silica* (Dr. A. G. Jhingran, Delhi); and *Rare Earths* (Dr. P. B Sarkar, Calcutta). To all these contributors and institutions, we are greatly indebted for their assistance and co-operation. We are also grateful to Prof. A. F. Hill, Botanical Museum, Harvard University, U.S.A., Rev. Fr. H. Santapau, St. Xavier's College, Bombay and Shri M. B. Raizada, Dehra Dun, for their kind help in checking plant nomenclature: to the President, Forest Research Institute, Dehra Dun; Director, Indian Agricultural Research Institute, New Delhi; Superintendent, Lal Bagh Garden, Bangalore; and Director of Arts, Indian Council of Agricultural Research, New Delhi, and various other specialists and institutions for the supply of illustrations and other material help afforded in the compilation of the articles. Our sincere gratitude is due to Dr. Atma Ram, Director-General and other members of the Editorial

Committee, and to Dr. Nihar Ranjan Ray, Chairman, Executive Council, Publications & Information Directorate, for their guidance and keen interest in the execution of the project. Sincere appreciation is also due to all the staff engaged on this national project for their unstinted labour and co-operation.

The Editorial Committee has suffered recently a serious loss by the demise, on January 18, 1969, of Dr. Baini Prasad, who had been associated with this work ever since 1948. In addition to general guidance and constant encouragement he gave to this work, he supervised the work connected with the editing of the articles on Animals & Animal Products. We wish to place on record our sincere gratitude and deep appreciation for the services he rendered to this project.

Recently, Shri R. C. Sawhney, one of our senior colleagues associated with this work ever since the first volume, retired from service on June 6, 1969 on attaining the age of superannuation. Shri Sawhney served this project in various capacities and our sincere appreciations go to him for all his devoted services.

This volume bears, like its predecessors, the imprint of Shri K. R. Ramanathan, one of our senior-most colleagues, who has been associated with this series for the past twenty and odd years. There has been no area connected with the preparation of this series with which he is not at home—whether it concerns the determination of the correct botanical identity of an economic plant or the chemical composition of the parts of the plant or the position of a crop in the economy of the country, or the likely sources within the country for information about less known plants. Even the entries under animals and minerals have benefited by his overall review. His sustained and untiring efforts are largely responsible for the completion of this volume.

We are indebted to Shri S. B. Deshaprabhu, who has been responsible for the excellence of production of this volume as well as the earlier ones. The care he has bestowed in the selection and preparation of illustrative material, rendering the manuscript press ready, and his vigilance during the printing of the volume have made it possible to adhere to a tight time schedule and bring out the volume expeditiously.

To our printers, Sree Saraswaty Press Ltd, Calcutta, we are grateful for a fine and expeditious job. We are particularly obliged to Shri S. K. Mitra Rai for his unfailing co-operation and personal interest in the printing of this volume.

The nature of the work involved, the increasing volume of literature to be carefully scrutinized and the critical appraisal to be made of the data derived from heterogenous sources, all take time and set a limit to the speeding up of compilation, particularly in maintaining the standard expected of this work. Everyone connected with this project is fully aware of the urgency to complete the remaining volumes as quickly as possible, and every effort is being made to complete the task without further delay.

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LIST OF ILLUSTRATIONS

PLATES

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LIST OF BOOKS REFERRED TO

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Vavilov	The Origin, Variation, Immunity and Breeding of Cultivated Plants, by N. I. Vavilov, translated from the Russian by K. Starr Chester (The Chronica Botanica Co., Waltham), Chronica Botanica, Vol. 13, No. 1/6, 1951.
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Venkataratnam	Horticulture in Central India, by L. Venkataratnam (Directorate of Extension, Ministry of Food & Agriculture, New Delhi), 1960.
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von Loesecke, 1942	Outlines of Food Technology, by H. W. von Loesecke (Reinhold Publishing Corp., New York), 1942.
Wallis	Textbook of Pharmacognosy, by T. E. Wallis (J. & A. Churchill Ltd., London), 3rd edn, 1955.
Ward	Pimento, by J. F. Ward (The Government Printer, Kingston, Jamaica), 1961.
Warth	The Chemistry and Technology of Waxes, by A. H. Warth (Reinhold Publishing Corp., New York), 2nd edn, 1956.
Watson	Grassland and Grassland Products, by S. J. Watson (Edward Arnold & Co., London), 1951.
Watt, G.	*See* C.P. & D.E.P.
Watt & Breyer-Brandwijk	The Medicinal and Poisonous Plants of Southern and Eastern Africa, by J. M. Watt & M. G. Breyer-Brandwijk (E. & S. Livingstone Ltd., Edinburgh), 2nd edn, 1962.
Webber & Batchelor	The Citrus Industry, edited by H. J. Webber & L. D. Batchelor (University of California Press, California), 2 vols., 1946.
Webster	Gems: Their Sources, Descriptions and Identification, by R. Webster (Butterworth & Co. Ltd., London), 2 vols., 1962.
Wehmer	Die Pflanzenstoffe, by C. Wehmer (Gustav Fischer, Jena), 2 vols., 1929-1931; and supplement, 1935.
Weindling	Long Vegetable Fibres: Manila, Sisal, Jute, Flax, and Related Fibres of Commerce, by L. Weindling (Columbia University Press, New York), 1947.
Weinstein	The World of Jewel Stones, by M. Weinstein (Sir Isaac Pitman & Sons Ltd., London), 1959.
West *et al.*, 1966	Textbook of Biochemistry, by E. S. West, W. R. Todd, H. S. Mason & J. T. Van Bruggen (The Macmillan Co., New York), 4th edn, 1966.
Whistler & BeMiller	Industrial Gums: Polysaccharides and Their Derivatives, edited by R. L. Whistler & J. N. BeMiller (Academic Press, Inc., New York), 1959.
Whistler & Smart	Polysaccharide Chemistry, by R. L. Whistler & C. L. Smart (Academic Press, Inc., New York), 1953.

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Willis	..	A Dictionary of the Flowering Plants and Ferns, by J. C. Willis (University Press, Cambridge), 6th edn, 1948.
Winton & Winton	..	The Structure and Composition of Foods, by A. L. Winton & K. B. Winton (John Wiley & Sons, New York), 4 vols., 1935.
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Witt	..	Descriptive List of Trees, Shrubs, Climbers and Economic Herbs of the Northern and Berar Forest Circles, Central Provinces, by D. O. Witt (Pioneer Press, Allahabad), 1916.
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Woodrow	..	Gardening in India, by G. M. Woodrow (Thacker, Spink & Co., Bombay), 1903.
Woodson *et al.*	..	Rauwolfia: Botany, Pharmacognosy, Chemistry & Pharmacology, by R. E. Woodson and others (Little, Brown and Co., Boston), 1957.
Worthington	..	Ceylon Trees, by T. B. Worthington (The Colombo Apothecaries' Co. Ltd., Colombo), 1959.
Wren	..	Potter's New Cyclopaedia of Botanical Drugs and Preparations, by R. C. Wren; re-edited and enlarged by R. W. Wren (Potter & Clarke Ltd., London), 7th edn, 1956.
Yamashita	..	Cultivated Plants and Their Relatives, edited by Kosuke Yamashita (Kyoto University, Kyoto, Japan), 1965.
Yegna Narayan Aiyer	..	Field Crops of India with special reference to Mysore, by A. K. Yegna Narayan Aiyer (The Bangalore Printing & Publishing Co. Ltd., Bangalore), 5th edn, 1958.
Yegna Narayan Aiyer, 1950	..	Feeds and Fodders, by A. K. Yegna Narayan Aiyer (The Bangalore Printing & Publishing Co. Ltd., Bangalore), 1950.
Youngken	..	Text Book of Pharmacognosy, by H. W. Youngken (The Blakiston Co., Philadelphia), 6th edn, 1950.
Zielinski	..	Modern Systematic Pomology, by Q. B. Zielinski (W.M.C. Brown Company, Inc.—Dubuque, Iowa), 1955.
Zukovskij	..	Cultivated Plants and Their Wild Relatives, by P. M. Zukovskij, abridged translation by P. S. Hudson (Commonwealth Agricultural Bureaux, Farnham Royal), 1962.

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Acta chem. scand.	Acta Chemica scandinavia. Kobenhavn.
Acta phytother., Amst.	Acta Phytotherapeutica. Amsterdam.
Advanc. Fd Res.	Advances in Food Research. New York.
Advanc. hort. Sci.	Advances in Horticultural Science. Oxford.
Agra Univ. J. Res. (*Sci.*)	Agra University Journal of Research (Science). Agra.
Agric. Anim. Husb., Uttar Pradesh	Agriculture and Animal Husbandry. Uttar Pradesh, Lucknow.
Agric. Handb. U.S. Dep. Agric.	Agriculture Handbook. United States Department of Agriculture. Washington, D.C.
Agric. J. India	Agricultural Journal of India. Pusa.
Agric. Ledger	Agricultural Ledger. Calcutta.
Agric. Live-Stk India	Agriculture and Live Stock in India. New Delhi.
Agric. Marketing	Agricultural Marketing. Nagpur.
Agric. Pakist.	Agriculture, Pakistan. Karachi.
Agric. Res.	Agricultural Research. New Delhi.
Agric. Res., Wash.	Agricultural Research. Washington, D.C.
Agric. Situat. India	Agricultural Situation in India. New Delhi.
Agriculture, Lond.	Agriculture. London.
Allahabad Fmr	Allahabad Farmer. Allahabad.
Amer. hort. Mag.	American Horticultural Magazine. Washington, D.C.
Amer. J. Bot.	American Journal of Botany. Lancaster, Pa.
Amer. J. Pharm.	American Journal of Pharmacy. Philadelphia, Pa.
Amer. Perfum.	American Perfumer. New York.
Andhra agric. J.	Andhra Agricultural Journal. Bapatla.
Ann. Biochem.	Annals of Biochemistry and Experimental Medicine. Calcutta.
Ann. Bogor.	Annales Bogorienses. Buitenzorg.
Ann. intern. Med.	Annals of Internal Medicine. Ann Arbor. Mich.
Ann. Mo. bot. Gdn	Annals of Missouri Botanical Garden. St. Louis, Mo.
Ann. N.Y. Acad. Sci.	Annals of the New York Academy of Sciences. New York.
Ann. R. bot. Gdn Calcutta	Annals of the Royal Botanic Garden, Calcutta. Calcutta.
Annu. Rep. cent. Fd technol. Res. Inst., Mysore	Annual Report. Central Food Technological Research Institute. Mysore.
Annu. Rep. Dep. Atomic Energy, India	Annual Report of the Department of Atomic Energy, India. Bombay.
Annu. Rep. Indian cent. Sugarcane Comm.	Annual Report. Indian Central Sugarcane Committee. Delhi.
Annu. sci. Rep. Indian agric. Res. Inst.	Annual Scientific Report of the Indian Agricultural Research Institute. New Delhi.
Antibiot. & Chemother.	Antibiotics & Chemotherapy. New York.
Araneta J. Agric.	Araneta Journal of Agriculture. Philippines.
Arch. int. Pharmacodyn.	Archives internationales de pharmacodynamie (et de therapie). Bruxelles.
Arch. Pharm., Berl.	Archiv der Pharmazie. Berlin.
Arecan. Bull.	Arecanut Bulletin. Kozhikode.
Aust. J. agric. Res.	Australian Journal of Agricultural Research. Melbourne.
Aust. J. Bot.	Australian Journal of Botany. Melbourne.
Aust. J. Chem.	Australian Journal of Chemistry. Melbourne.
Aust. J. exp. Biol. med. Sci.	Australian Journal of Experimental Biology and Medical Sciences. Melbourne.
Aust. J. sci. Res.	Australian Journal of Scientific Research. Melbourne.
Biochem. J.	Biochemical Journal. Cambridge.
Biol. Abstr.	Biological Abstracts. Philadelphia, Pa.
Blumea	Blumea. Leiden.
Bombay Technol.	Bombay Technologist. Bombay.
Bot. Bull. Acad. sinica	Botanical Bulletin of Academia Sinica. Shanghai.
Bot. Mem., Univ. Bombay	Botanical Memoirs, University of Bombay. Bombay.
Bot. Mus. Leafl. Harv.	Botanical Museum Leaflets. Harvard University. Cambridge, Mass.
Bot. Rev.	Botanical Review. Lancaster, Pa.
Brit. J. Pharmacol.	British Journal of Pharmacology and Chemotherapy. London.
Brit. J. Psychiat.	British Journal of Psychiatry. London.
Brittonia, N.Y.	Brittonia. New York.

Bull. agric. Congo belge	..	Bulletin agricole du Congo belge. Bruxelles.
Bull. appl. Bot. Pl.-Breed.	..	Bulletin of Applied Botany, of Genetics and Plant Breeding. Leningrad.
Bull. bot. Soc. Beng.	..	Bulletin of the Botanical Society of Bengal. Calcutta.
Bull. bot. Surv. India	..	Bulletin of the Botanical Survey of India. Calcutta.
Bull. Calcutta Sch. trop. Med.	..	Bulletin of the Calcutta School of Tropical Medicine. Calcutta.
Bull. cent. Fd technol. Res. Inst., Mysore	..	Bulletin. Central Food Technological Research Institute. Mysore.
Bull. cent. Leath. Res. Inst., Madras	..	Bulletin of the Central Leather Research Institute. Madras.
Bull. cent. Res. Inst., Univ. Kerala	..	Bulletin of the Central Research Institute, University of Kerala. Trivandrum.
Bull. Coun. sci. industr. Res. Aust.	..	Bulletin. Council for Scientific and Industrial Research. Australia. Melbourne.
Bull. Dep. Agric. Bombay	..	Bulletin. Department of Agriculture, Bombay. Bombay.
Bull. Dep. Agric. Madras	..	Bulletin. Department of Agriculture, Madras. Madras.
Bull. Dep. Fish., Ceylon	..	Bulletin. Department of Fisheries. Ceylon.
Bull. Dep. Ind. & Comm., Industr. Lab., Hyderabad	.	Bulletin. Department of Industries & Commerce, Industrial Laboratory, Hyderabad, Hyderabad.
Bull. Dep. Ind. Comm. United Provinces., N.S.		Bulletin. Department of Industries and Commerce, United Provinces of Agra and Oudh. New Series. Allahabad.
Bull. Dep. sci. industr. Res. N.Z.	..	Bulletin. Department of Scientific and Industrial Research, New Zealand, Wellington.
Bull. econ. Indoch.	..	Bulletin economique de l'Indochine. Hanoi.
Bull. Fla agric. Exp. Sta.	..	Bulletin. Florida Agricultural Experiment Station. Gainesville. Fla.
Bull. For. Dep., Uttar Pradesh	..	Bulletin. Forest Department, Uttar Pradesh. Allahabad.
Bull. geol. Surv. India, Ser. A	..	Bulletin of the Geological Survey of India. Series A. Economic Geology. Calcutta.
Bull. imp. Inst., Lond.	..	Bulletin of the Imperial Institute. London.
Bull. Indian Cocon. Comm.	..	Bulletin. Indian Central Coconut Committee. Ernakulam.
Bull. Indian Coun. agric. Res.	..	Bulletin. Indian Council of Agricultural Research. New Delhi.
Bull. Jard. bot. Brux.	..	Bulletin du Jardin botanique de l'Etat à Bruxelles. Bruxelles.
Bull. Minist. Agric., Lond.	..	Bulletin. Ministry of Agriculture and Fisheries. London.
Bull. Miss. agric. Exp. Sta.	..	Bulletin of the Mississippi Agricultural Experiment Station. State College. Jackson. Miss.
Bull. nat. bot. Gdns, Lucknow	..	Bulletin. National Botanic Gardens. Lucknow.
Bull. nat. Inst. Sci. India	..	Bulletin of the National Institute of Sciences of India. New Delhi.
Bull. Org. sci. Res. Indonesia	..	Bulletin of the Organization for Scientific Research in Indonesia. Djakarta.
Bull. Pharmacogn. Lab.	..	Bulletin. Pharmacognosy Laboratory. Ministry of Health. Govt. of India. New Delhi.
Bull. reg. Res. Lab., Jammu	..	Bulletin of the Regional Research Laboratory, Jammu. Jammu-Tawi.
Bull. R. trop. Inst., Amst.	..	Bulletin of the Royal Tropical Institute, Amsterdam.
Bull. sci. industr. Res. Org. Aust.		Bulletin. Commonwealth Scientific and Industrial Research Organization, Australia. Melbourne.
Bull. U.S. Bur. Pl. Ind.	..	Bulletin. United States Department of Agriculture. Bureau of Plant Industry. Washington, D.C.
Bull. Wash. agric. Exp. Sta.	..	Bulletin. Agricultural Experiment Stations, State College of Washington. D.C.
Bur. agric. industr. Chem., U.S. Dep. Agric.	..	Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration. United States Department of Agriculture. Philadelphia, Pa.
Calcutta Rev.	..	Calcutta Review. Calcutta.
Calif. Agric.	..	California Agriculture. Berkeley. California.
Canad. J. Bot.	..	Canadian Journal of Botany. Ottawa.
Canad. J. Chem.	..	Canadian Journal of Chemistry. Ottawa.
Canad. J. Pl. Sci.	..	Canadian Journal of Plant Science. Ottawa.
Canad. Miner. Yearb.	..	Canadian Minerals Yearbook. Ottawa.
Cancer Res.	..	Cancer Research. Baltimore. Md.
Candollea	..	Candollea. Geneve.
Cashew & Pepper Bull.	..	Cashew and Pepper Bulletin. Cochin.
Chem. Abstr.	..	Chemical Abstracts. Easton, Pa.
Chem. Age India	..	Chemical Age of India. Bombay.
Chem. Engng World	..	Chemical Engineering World. Bombay.
Chem. & Ind.	..	Chemistry and Industry. London.
Chemurg. Dig.	..	Chemurgic Digest. Columbus, Ohio.
Chem. Weekly	..	Chemical Weekly. Bombay.
Chim. et Industr.	..	Chimie et Industrie. Paris.

Chron. bot.	Chronica Botanica. Waltham, Mass.
Circ. Calif. agric. Ext. Serv.	Circular. California Agricultural Extension Service. Berkeley. California.
Circ. Fed. Exp. Sta. Puerto Rico	Circular. Federal Experiment Station in Puerto Rico. Mayaguez.
Circ. U.S. Dep. Agric.	Circular. United States Department of Agriculture. Washington. D.C.
Colon. Pl. Anim. Prod.	Colonial Plant and Animal Products. London.
Commun. R. trop. Inst. Amst.	Communication. Royal Tropical Institute. Amsterdam.
Comp. Wood	Composite Wood. Dehra Dun.
Contr. Boyce Thompson Inst.	Contributions. Boyce Thompson Institute for Plant Research. Menasha. Wis.
Contr. Gray Herb. Harv.	Contributions from the Gray Herbarium of Harvard University. Cambridge. Mass.
C.R. Acad. Sci., Paris	Compte rendu hebdomadaire des seances de l'Academie des sciences. Paris.
Curr. Sci.	Current Science. Bangalore.
Curtis's bot. Mag.	Curtis's Botanical Magazine. London.
Def. Sci. J.	Defence Science Journal. New Delhi.
E. Afr. agric. J.	East African Agricultural Journal. Nairobi.
East. Met. Rev.	Eastern Metals Review. Calcutta.
East. Pharm.	Eastern Pharmacist. New Delhi.
Econ. Bot.	Economic Botany. Lancaster, Pa.
Emp. Commonw. Yearb.	Empire and Commonwealth Yearbook. London.
Emp. J. exp. Agric.	Empire Journal of Experimental Agriculture. Oxford.
Endeavour	Endeavour. London.
Engelhard Inds tech. Bull.	Engelhard Industries Technical Bulletin. Newark, N.J.
Euphytica	Euphytica. Netherlands Journal of Plant Breeding. Wageningen.
Excerpta bot.	Excerpta Botanica. Stuttgart.
Experientia	Experientia. Basel.
FAO Commod. Ser. Bull.	FAO Commodity Series Bulletin. Rome.
FAO nutr. Stud.	FAO Nutritional Studies. Rome.
FAO Pl. Prot. Bull.	FAO Plant Protection Bulletin. Rome.
Farm Bull.	Farm Bulletin. Indian Council of Agricultural Research. New Delhi.
Farmer	Farmer. Bombay.
Fertil. News	Fertiliser News. New Delhi.
Fettchem. Umsch.	Fettchemische Umschau. Stuttgart.
Fibres	Fibres. London.
Field Crop Abstr.	Field Crop Abstracts. Aberystwyth.
Fieldiana, Bot.	Fieldiana. Botany. Chicago. Ill.
Fmg in S. Afr.	Farming in South Africa. Pretoria.
Fmrs' Bull. U.S. Dep. Agric.	Farmers' Bulletin. United States Department of Agriculture. Washington. D.C.
Food Pres. Quart.	Food Preservation Quarterly. Sydney.
Food Res.	Food Research. Champaign, Ill.
Food Sci.	Food Science. Mysore.
Food Sci. Abstr.	Food Science Abstracts. London.
Food Technol., Aust.	Food Technology in Australia. Sydney.
Food Technol., Champaign	Food Technology. Champaign, Ill.
For. Abstr.	Forestry Abstracts. Farnham Royal.
For. Bull., Econ. Ser.	Forest Bulletin. Economy Series. Delhi.
Foreign Agric.	Foreign Agriculture. Washington, D.C.
For. Res. India	Forest Research in India (and Burma). Calcutta.
Gardening	Gardening. Lucknow.
Gas Oil Pwr	Gas and Oil Power. London.
Gdnrs' Chron.	Gardeners' Chronicle and Agricultural Gazette. London.
Gdns' Bull.	Gardens' Bulletin. Straits Settlements. Singapore.
Handb. Inst. Nutr. Philipp.	Handbook. Institute of Nutrition. Philippines. Manila.
Helv. chim. acta	Helvetica chimica acta. Basel.
Heredity	Heredity. London.
Hilgardia	Hilgardia. Berkeley. California.
Himachal Hort.	Himachal Horticulture. Simla.
Hlth Bull.	Health Bulletin. New Delhi.

Hort. Abstr.	Horticultural Abstracts. East Malling.
Hort. Advance	Horticultural Advance. Saharanpur.
Ind.-Com J.	Ind-Com. Journal. Madras.
Indian Agriculturist	Indian Agriculturist. Calcutta.
Indian Bee J.	Indian Bee Journal. Naini Tal.
Indian Ceram.	Indian Ceramics. Calcutta.
Indian Cocon. J.	Indian Coconut Journal. Ernakulam.
Indian Coffee	Indian Coffee. Bangalore.
Indian Fd Packer	Indian Food Packer. Bombay.
Indian Fmg	Indian Farming. New Delhi.
Indian Fmg, N.S.	Indian Farming. New Series. New Delhi.
Indian For.	Indian Forester. Dehra Dun.
Indian For. Bull., N.S.	Indian Forest Bulletin, New Series. Dehra Dun.
Indian For. Leafl.	Indian Forest Leaflets. Dehra Dun.
Indian For. Rec.	Indian Forest Records. Dehra Dun.
Indian For. Rec., N.S., Bot.	Indian Forest Records. New Series. Botany. Dehra Dun.
Indian For. Rec., N.S., Chem.	Indian Forest Records. New Series. Chemistry. Dehra Dun.
Indian For. Rec., N.S., Chem. & Minor For. Prod.	Indian Forest Records. New Series. Chemistry and Minor Forest Products. Dehra Dun.
Indian For. Rec., N.S., Mycol.	Indian Forest Records. New Series. Mycology. Dehra Dun.
Indian For. Rec., N.S., Silvicult.	Indian Forest Records. New Series. Silviculture. Dehra Dun.
Indian For. Rec., N.S., Timb. Mech.	Indian Forest Records. New Series. Timber Mechanics. Dehra Dun.
Indian For. Rec., N.S., Util.	Indian Forest Records. New Series. Utilisation. Dehra Dun.
Indian Hort.	Indian Horticulture. New Delhi.
Indian hort. Abstr.	Indian Horticultural Abstracts. New Delhi.
Indian J. agric. Sci.	Indian Journal of Agricultural Science. New Delhi.
Indian J. Agron.	Indian Journal of Agronomy. New Delhi.
Indian J. appl. Chem.	Indian Journal of Applied Chemistry. Calcutta.
Indian J. Chem.	Indian Journal of Chemistry. New Delhi.
Indian J. Ent.	Indian Journal of Entomology. New Delhi.
Indian J. exp. Biol.	Indian Journal of Experimental Biology. New Delhi.
Indian J. Fish.	Indian Journal of Fisheries. New Delhi.
Indian J. Genet.	Indian Journal of Genetics and Plant Breeding. New Delhi.
Indian J. Hort.	Indian Journal of Horticulture. New Delhi.
Indian J. med. Res.	Indian Journal of Medical Research. Calcutta.
Indian J. med. Sci.	Indian Journal of Medical Sciences. Bombay.
Indian J. Pharm.	Indian Journal of Pharmacy. Bombay.
Indian J. Phys.	Indian Journal of Physics. Calcutta.
Indian J. Physiol.	Indian Journal of Physiology and Allied Sciences. Calcutta.
Indian J. Pl. Physiol.	Indian Journal of Plant Physiology. New Delhi.
Indian J. Technol.	Indian Journal of Technology. New Delhi.
Indian J. vet. Sci.	Indian Journal of Veterinary Science and Animal Husbandry. New Delhi.
Indian Live-Stk	Indian Live-Stock. New Delhi.
Indian med. Gaz.	Indian Medical Gazette. Calcutta.
Indian Min. & Engng J.	Indian Mining and Engineering Journal. Bombay.
Indian Miner.	Indian Minerals. Calcutta.
Indian Miner. Yearb.	Indian Minerals Yearbook. Nagpur.
Indian Oilseeds J.	Indian Oilseeds Journal. Hyderabad.
Indian Oil & Soap J.	Indian Oil and Soap Journal. Calcutta.
Indian Pat.	Indian Patent. Calcutta.
Indian Perfum.	Indian Perfumer. Kanpur.
Indian Pharm.	Indian Pharmacist. Calcutta.
Indian Phytopath.	Indian Phytopathology. New Delhi.
Indian Pulp Pap.	Indian Pulp and Paper. Calcutta.
Indian Seafoods	Indian Seafoods. Ernakulam.
Indian Soap J.	Indian Soap Journal. Calcutta.

Indian vet. J.	Indian Veterinary Journal. Madras.
Indian zool. Mem.	Indian Zoological Memoirs. Calcutta.
Industr. Engng Chem.	Industrial and Engineering Chemistry. Easton, Pa.
Industr. India	Industrial India. Bombay.
Industry, Calcutta	Industry. Calcutta.
Iowa Fm Sci.	Iowa Farm Science. Ames.
Iowa St. J. Sci.	Iowa State Journal of Science. Ames.
IS	Indian Standards. New Delhi.
ISI Bull.	ISI Bulletin. New Delhi.
Izv. Akad. Nauk tadzh. SSR	Izvestiya Akademii nauk Tadzhikskoi SSR. Stalinabad.
J. agric. Fd Chem.	Journal of Agricultural and Food Chemistry. Easton, Pa.
J. agric. Res.	Journal of Agricultural Research. Washington, D.C.
J. Agric. trop.	Journal d'Agriculture tropicale et de Botanique Appliquee. Paris.
J. Amer. chem. Soc.	Journal of the American Chemical Society. Easton, Pa.
J. Amer. Oil Chem. Soc.	Journal of the American Oil Chemists' Society. Chicago. Ill.
J. Amer. pharm. Ass., sci. Edn	Journal of the American Pharmaceutical Association. Scientific Edition. Columbus. Ohio.
J. Annamalai Univ.	Journal of the Annamalai University. Annamalainagar.
J. Arnold Arbor.	Journal of the Arnold Arboretum. Lancaster, Pa.
J. Asiat. Soc. Beng.	Journal of the Asiatic Society of Bengal. Calcutta.
J. Asiat. Soc. Sci.	Journal of the Asiatic Society, Science. Calcutta.
J. Ass. Physicians India	Journal of the Association of Physicians of India. Lucknow and Bombay.
J. Beng. nat. Hist. Soc.	Journal. Bengal Natural History Society. Darjeeling.
J. biol. Chem.	Journal of Biological Chemistry. Baltimore, Md.
J. Bombay nat. Hist. Soc.	Journal of the Bombay Natural History Society. Bombay.
J. chem. Soc.	Journal of the Chemical Society. London.
J. Coun. sci. industr. Res., Aust.	Journal of the Council for Scientific and Industrial Research. Australia. Melbourne.
J. Ecol.	Journal of Ecology. London.
J. econ. Ent.	Journal of Economic Entomology. Geneva, N.Y.
J. exp. Biol.	Journal of Experimental Biology. Cambridge.
J. Fd Sci.	Journal of Food Science, Champaign, Ill.
J. Fd Sci. & Technol.	Journal of Food Science and Technology. Mysore.
J. Genet.	Journal of Genetics. Cambridge.
J. hort. Sci.	Journal of Horticultural Sciences. London.
J. Indian bot. Soc.	Journal of the Indian Botanical Society. Madras.
J. Indian chem. Soc.	Journal of the Indian Chemical Society. Calcutta.
J. Indian chem. Soc., industr. Edn	Journal of the Indian Chemical Society. Industrial and News Edition. Calcutta.
J. Indian Inst. Sci.	Journal of the Indian Institute of Science. Bangalore.
J. Indian Leath. Technol. Ass.	Journal of Indian Leather Technologists' Association. Kanpur.
J. Indian Soc. Soil Sci.	Journal of the Indian Society of Soil Science. New Delhi.
J. Instn Chem. India	Journal and Proceedings of the Institution of Chemists, India. Calcutta.
J. Linn. Soc., Bot.	Journal of the Linnean Society. Botany. London.
J. Mar. biol. Ass. U.K.	Journal of the Marine Biological Association of the United Kingdom. Plymouth.
J. nat. Cancer Inst.	Journal of the National Cancer Institute. Washington. D.C.
J. nat. Inst. agric. Bot.	Journal of the National Institute of Agricultural Botany. Cambridge.
J. Nutr.	Journal of Nutrition. Philadelphia, Pa.
J.N.Y. bot. Gdn	Journal of the New York Botanical Garden. New York.
J. Oil Technol. Ass. India	Journal and Proceedings of the Oil Technologists' Association, India. Kanpur.
J. org. Chem.	Journal of Organic Chemistry. Easton, Pa.
J. Osmania Univ.	Journal of Osmania University. Hyderabad.
J. Pharm., Lond.	Journal of Pharmacy and Pharmacology. London.
J. pharm. Sci.	Journal of the Pharmaceutical Science. Columbus. Ohio.
J.R. hort. Soc.	Journal of the Royal Horticultural Society. London.
J. Sci. Fd Agric.	Journal of the Science of Food and Agriculture. London.
J. sci. industr. Res.	Journal of Scientific and Industrial Research. New Delhi.
J. sci. Res. Indonesia	Journal for Scientific Research in Indonesia. Djakarta.

J. Sci. & Technol.	Journal of Science and Technology, India. Kanpur.
J. Soc. chem. Ind., Lond.	Journal of the Society of Chemical Industry. London.
J. Soc. Dy. Col.	Journal of the Society of Dyers and Colourists. Bradford.
J. Timb. Dryers' & Pres. Ass. India	Journal of the Timber Dryers' and Preservers' Association of India. Dehra Dun.
J. Univ. Bombay	Journal of the University of Bombay. Bombay.
J. Univ. Bombay, N.S.	Journal of the University of Bombay. New Series. Bombay.
J. zool. Soc. India	Journal of the Zoological Society of India. Calcutta.
Japan Sci. Rev., Biol Sci.	Japan Science Review. Biological Sciences. Tokyo.
Jt Publ. imp. agric. Bur.	Joint Publications. Imperial (Commonwealth) Agricultural Bureau. Aberystwyth.
Kanpur agric. Coll. J.	Kanpur Agricultural College Journal. Kanpur.
Kew Bull.	Kew Bulletin. Royal Botanic Gardens, Kew.
Kew Bull. Addl Ser.	Kew Bulletin. Additional Series. Royal Botanic Gardens, Kew.
Khadi Gramodyog	Khadi Gramodyog. Bombay.
Labdev. J. Sci. & Technol.	Labdev. Journal of Science and Technology. Kanpur.
Lal-Baugh	Lal-Baugh. Bangalore.
Leath. Sci.	Leather Science. Madras.
Madras agric. J.	Madras Agricultural Journal. Coimbatore.
Malay. agric. J.	Malayan Agricultural Journal. Kuala Lumpur.
Malay. For.	Malayan Forester. Kuala Lumpur.
Malay. For. Rec.	Malayan Forest Records. Singapore.
Manufacturer	Manufacturer. Calcutta.
Mat. Veg.	Materiae Vegetabiles. The Hague.
McGraw-Hill Yearb. Sci. & Technol.	McGraw-Hill Yearbook of Science & Technology. New York.
Medicus, Karachi	Medicus. Karachi.
Mem. Dep. Agric. India, Bot.	Memoirs of the Department of Agriculture in India. Botanical Series. Pusa.
Mem. Dep. Agric. India, Chem.	Memoirs of the Department of Agriculture in India. Chemical Series. Pusa.
Mem. Dep. Agric. Madras	Memoirs of the Department of Agriculture, Madras. Madras.
Mem. Fac. Sci. Agric. Taihoku	Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University. Formosa.
Mem. geol. Surv. India	Memoirs of the Geological Survey of India. Calcutta.
Mem. Indian Mus.	Memoirs of the Indian Museum. Calcutta.
Miner. Markets	Mineral Markets. Bombay.
Misc. Bull., imp. Coun. agric. Res.	Miscellaneous Bulletin. Imperial Indian Council of Agricultural Research. New Delhi.
Mon. Bull. Miner. Statist. & Inform.	Monthly Bulletin of Mineral Statistics and Information. Nagpur.
Mysore agric. J.	Mysore Agricultural Journal. Bangalore.
Nature, Lond.	Nature. London.
Naturwissenschaften	Naturwissenschaften. Berlin.
NML Tech. J.	NML Technical Journal. Jamshedpur.
Nucl. India	Nuclear India. Bombay.
Nutr. Abstr. Rev.	Nutrition Abstracts and Reviews. Aberdeen.
Oils & Oilseeds J.	Oils & Oilseeds Journal. Bombay.
Pacif. Sci.	Pacific Science. Honolulu.
Pakist. J. For.	Pakistan Journal of Forestry. Abbottabad.
Pakist. J. Sci.	Pakistan Journal of Science. Lahore.
Pakist. J. sci. industr. Res.	Pakistan Journal of Scientific & Industrial Research. Karachi.
Pakist. J. sci. Res.	Pakistan Journal of Scientific Research. Lahore.
Palest. J. Bot., Jerusalem Ser.	Palestine Journal of Botany. Jerusalem Series. Jerusalem.
Parfum. u. Kosmetik	Parfümerie und Kosmetik. Heidelberg.
Perfum. essent. Oil Rec.	Perfumery and Essential Oil Record. London.
Pharmaceutist	Pharmaceutist. Bombay.
Pharm. J.	Pharmaceutical Journal and Pharmacist. London.
Philipp. Abstr.	Philippine Abstracts. Manila.
Philipp. Agric.	Philippine Agriculturist. Los Banos.
Philipp. J. Sci.	Philippine Journal of Science. Manila.
Phytochemistry	Phytochemistry. Oxford.
Phytopathology	Phytopathology. Lancaster, Pa.

Plant Breed. Abstr.	Plant Breeding Abstracts. Cambridge.
Plant Prot. Bull. New Delhi	Plant Protection Bulletin. New Delhi.
Platinum Met. Rev.	Platinum Metals Review. London.
Poona agric. Coll. Mag.	Poona Agricultural College Magazine. Poona.
Preslia	Preslia. Prague.
Proc. Acad. Sci. United Provinces	Proceedings of the Academy of Sciences of the United Provinces of Agra and Oudh. Allahabad.
Proc. Fla St. hort. Soc.	Proceedings of the Florida State Horticultural Society. Deland. Fla.
Proc. Indian Acad. Sci.	Proceedings of the Indian Academy of Sciences. Bangalore.
Proc. Indian Sci. Congr.	Proceedings of the Indian Science Congress. Calcutta.
Proc. Indo-Pacif. Fish. Coun.	Proceedings. Indo Pacific Fisheries Council. Bangkok.
Proc. Jap. Ass. Advanc. Sci.	Proceedings of the Japanese Association for the Advancement of Science. Tokyo.
Proc. nat. Acad. Sci. India	Proceedings of the National Academy of Sciences, India. Allahabad.
Proc. nat. Inst. Sci. India	Proceedings of the National Institute of Sciences of India. New Delhi.
Prod. Yearb. FAO	Production Yearbook, FAO. Rome.
Progr. Rep. Pacif. Coast Sta.	Progress Report of the Pacific Coast Stations. Ottawa.
Publ. Field Mus. nat. Hist., Bot. Ser.	Publication. Field Museum of Natural History. Botanical Series. Chicago. Ill.
Punjab Fr. J.	Punjab Fruit Journal. Lahore.
Punjab hort. J.	Punjab Horticultural Journal. Patiala.
Qd J. agric. Sci.	Queensland Journal of Agricultural Science. Brisbane.
Qualit. Plant. Mat. Veg.	Qualitas Plantarum et Materiae Vegetabiles. The Hague.
Quart. J. Crude Drug Res.	Quarterly Journal of Crude Drug Research. Amsterdam.
Quart. J. For.	Quarterly Journal of Forestry. London.
Rec. bot. Surv. India	Records of the Botanical Survey of India. Calcutta.
Rec. geol. Surv. India	Records of the Geological Survey of India. Calcutta.
Rec. Indian Mus.	Records of the Indian Museum. Delhi.
Reinwardtia	Reinwardtia. Kebun Raya.
Rep. Dep. Nutr. Govt. Bombay	Report. Department of Nutrition. Govt. of Bombay. Bombay.
Rep. Dep. Res. Univ. Travancore	Report. Department of Research. University of Travancore. Trivandrum.
Rep. essent. Oils Schimmel	Annual Report on Essential Oils, Aromatic Chemicals and Related Materials, Schimmel & Co., New York.
Rep. Innes hort. Instn	Report. John Innes Horticultural Institution. London.
Repert. Spec. Nov. Regni Veget.	Repertorium Specierum Novarum Regni Vegetabilis. Berlin.
Res. Bull. Panjab Univ., N.S., Sci. Sec	Research Bulletin of the Panjab University, New Series. Science Section. Chandigarh.
Res. & Ind.	Research & Industry. New Delhi.
Rev. Ser., Indian Coun. agric. Res.	Review Series. Indian Council of Agricultural Research. New Delhi.
Rhodora	Rhodora. Journal of the New England Botanical Club. Boston. Mass.
Riechstoffe u. Aromen	Riechstoffe und Aromen. Hanover.
Riz et Rizic.	Riz et Riziculture et Cultures Vivrieres Tropicales. Paris.
Science	Science. New York.
Sciences	Sciences. New York.
Sci. & Cult.	Science and Culture. Calcutta.
Sci. News Lett., Wash.	Science News Letter. Washington, D.C.
Sci. Progr.	Science Progress. Washington, D.C.
Sci. Reporter	Science Reporter. New Delhi.
Sci. Ser., Dep. Agric., Malaya	Scientific Series. Department of Agriculture. Federation of Malaya. Johore Bahru.
Seafood Tr. J.	Seafood Trade Journal. Cochin.
S. Indian Hort.	South Indian Horticulture. Coimbatore.
Soap Perfum. Cosm.	Soap Perfumery & Cosmetics. London.
Spec. Bull. Dep. Agric. Punjab	Special Bulletin of the Department of Agriculture, Punjab.
Spec. Bull. Dep. Agric. Uttar Pradesh	Special Bulletin of the Department of Agriculture. Uttar Pradesh. Basti.
Spices Bull.	Spices Bulletin. Ernakulam.
Statist. Summ. Miner. Ind.	Statistical Summary of the Mineral Industry. London.
Svensk bot. Tidskr.	Svensk botanisk Tidskrift. Stockholm.
Tad Gud Parichaya	Tad Gud Parichaya. Bombay.
Taxon	Taxon. Utrecht.

Tech. Bull. N.Y. St. agric. Exp. Sta.	Technical Bulletin. New York State Agricultural Experiment Station, Geneva, N.Y.
Tech. Bull. U.S. Dep. Agric.	Technical Bulletin. United States Department of Agriculture. Washington, D.C.
Tetrahedron	Tetrahedron. London.
Tetrahedron Lett.	Tetrahedron Letter. London.
Times Rev. Ind., N.S.	The Times Review of Industry, New Series. London.
Tocklai exp. Sta. Memor.	Tocklai Experimental Station Memorandum. Assam.
Tohoku J. agric. Res.	Tohoku Journal of Agricultural Research. Sendai.
Trans. Amer. phil. Soc., N.S.	Transactions of the American Philosophical Society. New Series. Philadelphia. Pa.
Trans. Bose Res. Inst.	Transactions of the Bose Research Institute. Calcutta.
Trans. bot. Soc. Edinb.	Transactions and Proceedings of the Botanical Society of Edinburgh. Edinburgh.
Trans. Indian ceram. Soc.	Transactions of the Indian Ceramic Society. Calcutta.
Trans. R. Soc. Edinb.	Transactions of the Royal Society of Edinburgh. Edinburgh.
Trop. Abstr.	Tropical Abstracts. Amsterdam.
Trop. Agriculture, Trin.	Tropical Agriculture. Trinidad.
Trop. Agriculturist	Tropical Agriculturist and Magazine of the Ceylon Agricultural Society. Peradeniya.
Trudy biol. Inst., Frunze	Trudy Biologicheskogo Instituta Akademiya nauk Kirgizskoi SSR, Frunze.
Unasylva	Unasylva. Rome.
Univ. Rajputana Stud., Med. Sec.	University of Rajputana Studies. Medical Section. Jaipur.
Vet. J.	Veterinary Journal. London.
Vijnan Parishad Anusandhan Patrika	Vijnan Parishad Anusandhan Patrika. Allahabad.
Watsonia	Watsonia. London.
World Crops	World Crops. London.
Yearb. Agric., U.S. Dep. Agric.	Yearbook of Agriculture. United States Department of Agriculture. Washington, D.C.
Zuchter	Zuchter. Zeitschrift fur theoretische und angewandte Genetik. Berlin.

RAW MATERIALS
VOL. VIII : Ph–Re

Ph

PHACELURUS Griseb. (*Gramineae*)

A very small genus of perennial grasses from warm parts of East Africa and Asia. One species occurs in India.

P. speciosus (Steud.) C. E. Hubbard syn. *Rottboellia speciosa* Hack.

D.E.P., III, 437 ; Fl. Br. Ind., VII, 152 ; Bor, *Indian For. Rec., N.S., Bot.*, 1941, **2**(1), Pl. XLVII.

A perennial tufted grass distributed in the western temperate Himalayas from Kashmir to Garhwal, found generally at elevations of 1,500–3,000 m. Rootstock very stout ; culms up to 1.5 m. high ; leaves up to 60 cm. long, hispid or glabrous with rough margins ; panicles greenish or purple ; grains oblong.

It is considered a fodder grass in the dry hill valleys above 1,500 m., where it is the only fodder grass found. It develops an extremely extensive and tough root system and may be useful in badly eroded areas (Bor, 1960, 200).

PHAIUS Lour. (*Orchidaceae*)

Fl. Br. Ind., V, 816 ; Fl. Malaya, I, 170, Fig. 28.

A genus of terrestrial or epiphytic herbs, distributed in the tropics of the Old World, Australia, Pacific Islands, and in Japan. About eight species occur in India.

Phaius spp. have long leaves and tall clustered stems, terminating in racemes of showy flowers. Some of these orchids are grown for ornament. Propagation is done by divisions of dormant pseudobulbs (Bailey, 1947, III, 2569).

P. tankervilliae Blume syn. *P. wallichii* Hook. f. (Fl. Br. Ind.) ; *P. grandifolius* Lindl. (BIHAR—*Tipui, tipui tangajji, daru yamjori ba*) is a terrestrial herb, with long ovoid pseudobulbs bearing beautiful fragrant flowers (8–12 cm. across), on stout scape, up to 140 cm. long, found in the eastern Himalayas and hills of Assam ; also recorded from marshy places along the streams in Bihar and Orissa. The herb is often grown in gardens. The scape and the leaves are reported to yield an indigo similar to that from *Indigofera* spp., containing indican. The pseudobulbs are said to be used for strengthening twine for fishing-nets (Wehmer, I, 190 ; Bressers, 154).

PHALAENOPSIS Blume (*Orchidaceae*)

Fl. Br. Ind., VI, 29.

A genus of mostly epiphytic herbs distributed in the Indo-Malaysian region. Four species occur wild in India, and some exotics have been introduced in gardens.

The genus includes some of the choicest of orchids ; but they are difficult to grow as they seldom afford opportunity for divisions and have to be reared from seed. Sometimes young plants appear on old flower stems : the ones bearing roots can be transferred to pots. These orchids are best grown attached to pieces of wood, coconut husk and tree-fern roots ; liquid manure yields good results (Gopalaswamiengar, 515 ; Fl. Malaya, I, 672 ; Bailey, 1947, III, 2570).

P. amabilis Blume, the well-known MOTH or MOON ORCHID, is grown in wooden baskets for its ornamental white flowers (c. 7–12 cm. across) tinted with yellow and a few red or purple spots on the labellum. The herb is reported to contain an alkaloid which is toxic to frogs (Gopalaswamiengar, 515 ; Firminger, 361 ; Wehmer, I, 187).

PHALARIS Linn. (*Gramineae*)

A small genus of annual or perennial grasses distributed in warm temperate regions. Five species are reported in India.

P. aquatica Linn. syn. *P. tuberosa* Linn. TOOWAMBA CANARY GRASS

Bor, 1960, 616 ; Anderson, *Iowa St. J. Sci.*, 1961, **36**(1), 43.

A tufted perennial grass, native of Mediterranean region, cultivated in India and other countries. Culms up to 1.5 m. tall, swollen at the base ; panicles usually cylindric or ovate-cylindric ; grain light brown, with finely striate surface.

This grass is well adapted to sub-tropical, winter rainfall climates. It associates well with clover. In recent trials in Nilgiris, it has given an average yield of 7,300 kg./ha. during the period November to March. It is cold tolerant and makes good growth in mild winter [Whyte *et al.*, 1959, 362 ; Rao & Ramalingam, *Madras agric. J.*, 1965, **52**, 271 ; Malik, *Indian Fmg, N.S.*, 1960–61, **10**(8), 9].

P. aquatica yields a nutritious and palatable forage. Analysis of the grass (from Australia) at the flowering stage gave the following values (dry basis): crude protein, 5.25; ether extr., 1.42; N-free extr., 51.53; fibre, 33.15; ash, 8.65; and phosphorus (P_2O_5), 0.30%. The grass can also be made into hay. Nutritive value of the hay is as follows: protein, 6.5; dig. protein, 4.1; and total dig. nutrients, 46.7%; nutritive ratio, 10.4 (Whyte *et al.*, 1959, 362; Rao & Ramalingam, loc. cit.; Shapter, *J. Coun. sci. industr. Res., Aust.*, 1935, **8**, 187; Morrison, 1008).

In Australia, ruminants grazing on pastures containing a large proportion of *P. aquatica*, occasionally develop a nervous disorder 'phalaris staggers'. The nature of the toxin is not clearly known. The toxic effect is attributed at least in part to the presence of tryptamine alkaloids such as N,N-dimethyl tryptamine, 5-methoxy-N,N-dimethyl tryptamine, and 5-hydroxy-N,N-dimethyl tryptamine (bufotenine) (Culvenor *et al.*, *Aust. J. Chem.*, 1964, **17**, 1301; Gallagher *et al.*, *Nature, Lond.*, 1964, **204**, 542).

The straw of *P. aquatica* can be processed along with wheat straw by the sulphate process for the production of pulp (*Chem. Abstr.*, 1959, **53**, 16531).

P. arundinacea Linn. REED CANARY GRASS

Fl. Br. Ind., VII, 221; Bor, 1960, 616; Anderson, *Iowa St. J. Sci.*, 1961, **36**(1), 37–42.

A robust perennial grass with creeping rhizomes and erect stem found in Kashmir at *c.* 1,665 m. It is variable, and a variety of it, var. *picta* Linn. (RIBBON GRASS) with striped leaves, is cultivated in the gardens for ornament. In Assam, this variety has escaped from cultivation in and around Shillong and has lost its varietal character.

The grass is considered useful for grazing when young, or as hay. Because of its strong creeping rhizomes, it is considered useful in anti-erosion work. Several strains have been developed in U.S.A. and Canada (Fl. Assam, V, 165; Hubbard, 249; Meredith, 88; Whyte *et al.*, 1959, 360).

Analysis of the grass from Jammu gave the following values (dry basis): protein, 14.46; ether extr., 2.21; carbohydrates, 41.09; crude fibre, 30.21; mineral matter, 10.25; calcium (CaO), 0.79; and phosphorus (P_2O_5), 0.98%. It makes a satisfactory hay when cut after the appearance of the first head. The hay contains: protein, 7.7; fat, 2.3; N-free extr., 44.3; fibre, 29.2; mineral matter, 7.6; calcium, 0.33; phosphorus, 0.16; dig. protein, 4.9; and total dig. nutrients, 45.1%; nutritive ratio, 8.2. The grass can also be ensiled (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 415; Morrison, 378, 1014).

The grass contains hordenine and 5-methoxy-N-methyl tryptamine. Certain unpalatable strains of the grass contained gramine ($C_{11}H_{14}N_2$, m.p. 133–34°) as the major alkaloid (Culvenor *et al.*, *Aust. J. Chem.*, 1964, **17**, 1301).

The seed is used as a bird feed (Schery, 422).

P. canariensis Linn. CANARY GRASS

Bor, 1960, 616; Anderson, *Iowa St. J. Sci.*, 1961, **36**(1), 57–61.

A tufted annual grass, native of western Mediterranean region, probably introduced into India. Culms erect, 20–120 cm. tall; leaves hairless; panicles ovate to ovate-oblong; grain tightly enclosed inside lemma and palea.

Canary grass is a pasture grass. It can also be made into hay. Analysis of the green forage (dry matter, 25.8%) gave the following average values (dry basis): crude protein, 13.1; ether extr., 3.7; crude fibre, 26.8; N-free extr., 47.0; ash, 9.4; calcium, 0.44; phosphorus, 0.29; and potassium, 3.17% (Pal & Singh, *Indian Fmg*, 1949, **10**, 423; Miller, 110, 294).

In Europe, the grains of the grass are valued as a bird feed and as a cereal. They are similar to ordinary cereals in composition and digestibility, but are deficient in calcium. They contain about 55 per cent of starch and 5–6 per cent of a yellow fatty oil having an agreeable taste. The grains are reported to be diuretic and are used in bladder diseases (Bailey, 1947, III, 2573; Hubbard, 247; *Chem. Abstr.*, 1936, **30**, 3035; Hoppe, 659; Mensier, 443; Steinmetz, I, 99).

P. minor Retz. SMALL CANARY GRASS

Fl. Br. Ind., VII, 221; Anderson, *Iowa St. J. Sci.*, 1961, **36**(1), 30–36.

DELHI—*Chiriya bajra.*

A tufted, procumbent annual found in the plains of western India and the Himalayas from Kashmir to Nepal, ascending to 1,500 m. Stems 30–100 cm. high, stout or slender; leaves 40–50 cm. long, glabrous; panicles ovate-oblong; seeds lens-shaped.

This is a common weed on cultivated land in the plains and is fairly common in Punjab. This grass is stated to be spreading rapidly in Nadia district of West Bengal. It is leafy, succulent, nutritive and palatable and with its numerous seeds which are easy to collect, shows a great promise as a winter forage crop. Recently it has attracted attention for its

FIG 1—PHALARIS MINOR—INFLORESCENCE

possible use as a fodder in rice-growing areas. It is known to be an adulterant of *P. aquatica*. A form with the lemma either absent or reduced is considered as a distinct variety, var. *nepalensis* (Trin.) Bor and is found in North-West Himalayas (Dabadghao *et al.*, *Sci. & Cult.*, 1951–52, **17**, 113; Dabadghao, ibid., 1951–52, **17**, 233; Choudhari, *Indian For.*, 1959, **85**, 606; Bor, 1960, 616).

The grass is rich in protein and is readily consumed by dairy cattle. Analysis of the grass (from Delhi) cut at the young and flowering stages gave the following values respectively (dry basis): crude protein, 19.04, 13.93; ether extr., 3.72, 5.18; N-free extr., 38.50, 31.32; fibre, 21.24, 29.90; ash, 17.5, 19.66; calcium (CaO), 1.3, 0.72; and phosphorus (P_2O_5), 0.89, 0.55% (Dabadghao *et al.*, loc. cit.).

Trials at Indian Agricultural Research Institute, New Delhi, on short duration grass-legume mixtures suitable for cultivation after the harvest of main paddy crop, showed a considerable increase in the protein content of the grass due to association of the grass with the legume, and also a higher output of total protein per acre (Dabadghao, loc. cit.).

In North Africa, the grass has been reported to be poisonous in young state, especially to horses (Whyte *et al.*, 1959, 360).

The seeds, used as a bird feed, contain (dry basis): protein, 15.31; ether extr., 7.60; N-free extr., 63.26; crude fibre, 7.84; total ash, 5.99; and phosphoric acid, 1.12% (Shapter, *J. Coun. sci. industr. Res., Aust.*, 1935, **8**, 187).

Phasemy Bean — *see* **Phaseolus**

PHASEOLUS Linn. (*Leguminosae; Papilionaceae*)

A genus of annual or perennial herbs or twiners found throughout the tropics and warm temperate regions of the world. About five species occur in India, three of them cultivated throughout the world mainly for their edible pods.

The genus *Phaseolus*, as circumscribed at present, includes mostly American species which have stipules not prolonged beyond insertion and the keel of the flower coiled into 1–5 turns. Most of the Asiatic species previously included under this genus have now been transferred to the genus *Vigna*. They comprise those species which have stipules prolonged beyond insertion and with keel erect, incurved, rarely coiled into a single spiral only. In addition to the above characters, the American and Asiatic species are further distinguished by differences in the characters of the seed, seedling leaves, shape of the pods, colouration of flowers and other floral characters. Further, the American species are susceptible to *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. and the Asiatic species to *Cercospora cruenta* Sacc. The Asiatic and the American species are also reported not to cross easily with one another. It is stated that the two geographical groups may form a homologous series, with centres of origin, one in America and the other in southern Asia. Recent studies of the seeds and seedlings of species of *Phaseolus* and *Vigna* appear to confirm that the Asiatic species are quite distinct from the American species and their assignment to *Vigna* seems more logical. Accordingly, all Indian species including *P. mungo* (*Urd*) and *P. aureus* (*Mung*), well known for their economic uses, will be dealt with under *Vigna* [Wilczek in Fl. Congo Belge et Ruanda Urundi, VI, 261; Ivanov, *Bull. appl. Bot. Pl.-Breed.*, 1928, **19**(2), 185; Tourneur, *Riz et Rizic.*, 1958, **4**, 131].

P. adenanthus G. F. W. Mey.

D.E.P., VI(1), 186; Fl. Br. Ind., II, 200.

BENG.—*Banbarbati*; TEL.—*Karalasana*; TAM. & MAL.—*Kattupayaru*.

ORAON—*Masikanda*; MUNDARI—*Tasad-chandoa*; BOMBAY—*Kullounda*.

A sub-glabrous perennial with tuberous roots found throughout the plains of India from the Himalayas to Kerala, but not cultivated. Leaves trifoliolate: leaflets, 7.5–10.0 cm. long; flowers very showy, red or light blue, fragrant; pods flat, 10–15 cm. long, 1.4 cm. broad, glabrous, much recurved, 10–15 seeded; seeds nearly circular, flat, 6 mm. in diam., black.

The plant is worth growing for ornament. The tuberous roots are eaten in Chota Nagpur in times of scarcity. A decoction of the plant is used in bowel complaints and strictures. The roots are used to stop excessive salivation (Dalziel, 254; Bressers, 45–46; Kirt. & Basu, I, 800).

P. coccineus Linn. syn. *P. multiflorus* Lam.
MULTIFLORA BEAN, SCARLET RUNNER BEAN

D.E.P., VI(1), 187; Hector, II, 671; Bailey, 1947, III, 2576, Fig. 2892–94.

A perennial with thickened tuberous roots, usually grown as an annual; stems slender and twining or bushy in some varieties; leaves trifoliolate; flowers showy, large, generally bright red in colour or occasionally white; pods 10–30 cm. long, slightly curved and plump, glabrous or faintly pubescent, with a stout beak; seeds large, broadly oblong, flattened, 1.8–2.5 cm. long, usually nearly black with red markings, rarely white.

This species is considered to have originated in Mexico and Guatemala where it is found wild. It includes three botanical varieties: var. *rubronanus* Bailey, a red-flowered bushy type; var. *albus* Bailey, the White Dutch Runner; and var. *albonanus* Bailey, a bush form with white seeds. It has been introduced into various countries including India and cultivated in gardens for its edible pods. The plant is also grown for ornamental purposes (Bailey, 1947, III, 2576; Yarnell, *Bot. Rev.*, 1965, **31**, 247; Zukovskij, 24).

This bean is difficult to cultivate satisfactorily in most parts of India. It thrives with little care on the hills, and can give good return, if properly attended to. Runner beans are sown from middle of August to middle of October in the plains and from beginning of April to end of June in the hills. Deep digging, heavy manuring and thorough preparation of the soil are essential for a good crop. The crop should be watered copiously in dry weather. The seeds are sown about 5 cm. deep and spaced 20–30 cm. in the row. Since the plants trail, staking is necessary. The red-flowered variety is used for ornamental screen planting and on arbors; the white-flowered variety is grown for the beans (Yarnell, loc. cit.; Firminger, 162; Gollan, 19; Purewal, 82).

P. coccineus has been successfully crossed with both *P. lunatus* Linn. and *P. vulgaris* Linn. (Yarnell, loc. cit.).

The tender young pods and the green shelled beans (seeds) are eaten as vegetable; the mature dry beans may be used as a pulse like other beans. The edible portion (59%) of the pods gave on analysis the following values: moisture, 58.3; protein, 7.4; fat, 1.0; carbohydrates, 29.8; fibre, 1.9; and mineral matter, 1.6%; calcium, 50; phosphorus, 160; iron, 2.6; thiamine, 0.34; riboflavin, 0.19; and vitamin C, 27 mg.; vitamin A, 57 I.U./100 g. The beans are a good source of vitamins of the B-group and contain a fair amount of iron. Analysis of the fresh, shelled beans gave the following values: moisture, 34.2; ether extr., 0.3; crude fibre, 12.2; nitrogen, 2.6; and ash, 2.8%; calcium, 60.6; phosphorus, 276.6; iron, 4.1; carotene, 0.034; thiamine, 0.538; riboflavin, 0.138; niacin, 2.3; and ascorbic acid, 0.2 mg./100 g. Gibberellins A_1, A_5, A_6 and A_8 have been found in immature beans. The dry beans yield 1–2 per cent of a brownish red fatty oil having the following characteristics: sp. gr.$^{15°}$, 0.920; $n^{40°}$, 1.476; sap. val., 190; iod. val., 141.2; solid. p., −12°; and unsapon. matter, 1–2% (Schery, 402; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 136; Nutritive Value of Indian Foods, 60, 97, 127; Munsell *et al.*, *Food Res.*, 1950, **15**, 34; Holman, *Nutr. Abstr. Rev.*, 1956, **26**, 277; Brian, *Sci. Progr.*, 1961, **49**, 1; Mensier, 445).

Roots contain 18.6 per cent of starch (amylose content, 27%) (*Hort. Abstr.*, 1964, **34**, 292).

P. lathyroides Linn. syn. *P. semierectus* Linn.
PHASEMY BEAN

Fl. Br. Ind., II, 201; Mayuranathan, 88.

A sub-erect, shrubby plant, 1.2–1.5 m. high, native of Central and South America and West Indies and found naturalized in Madras, Maharashtra and West Bengal. Leaves trifoliolate; leaflets glabrous when mature; flowers deep purple; pods 7.5–10.0 cm. × 0.3 cm., nearly cylindric, silvery pubescent when young and nearly glabrous when mature; seeds about 20, rectangular, 3.0–3.5 mm. long, dark brown.

Phasemy bean is a summer legume, but retains its leaves until heavily frosted; it shoots again from the

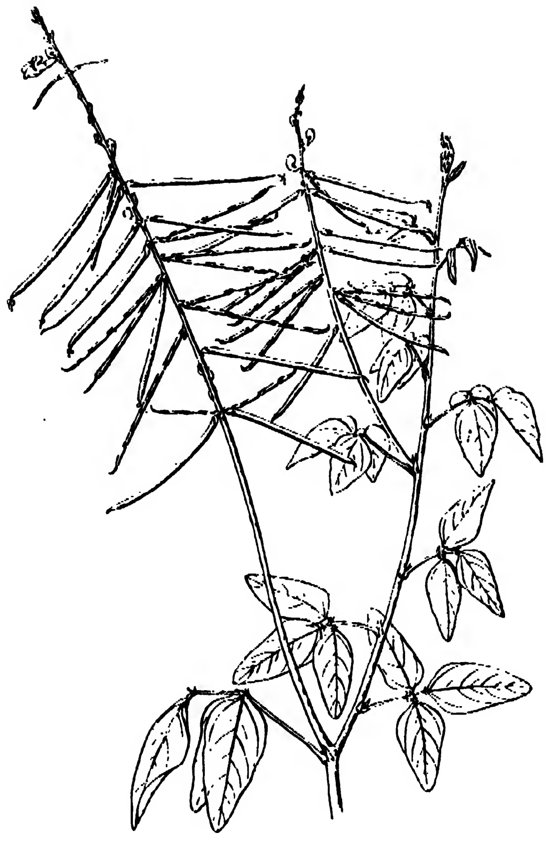

FIG. 2—PHASEOLUS LATHYROIDES—FRUITING BRANCH

base with the advent of spring rain and higher temperatures. It responds well to fertilizers. In pastures it is reported to combine well with *Paspalum scrobiculatum* and similar grasses. It can also be cut for hay or fed green to pigs. It is palatable and highly nutritive (Whyte *et al.*, 304).

It is fast growing and well adapted for green manuring; it becomes woody when mature and can be used, therefore, only when young. The plant is reported to have yielded about 23,520 kg. of green matter per hectare (Use of Leguminous Plants, 234; Burkill, II, 1708; Bavappa & Rao, *Madras agric. J.*, 1957, **44**, 287).

In the Philippines, the seeds are sometimes eaten as a substitute for green gram (Brown, 1941, II, 142).

P. lunatus Linn. syn. *P. inamoenus* Linn. DOUBLE BEAN, LIMA BEAN, BURMA BEAN, RANGOON BEAN

D.E.P., VI(1), 186; C.P., 880; Fl. Br. Ind., II, 200; Hector, II, 673.

HINDI—*Sem*; TAM.—*Khasi kollu*; PUNJAB—*Lobiya*; BOMBAY—*Dafal*.

A perennial or annual, native of Central or South America, and nearly naturalized in Africa; it has been introduced into India and other countries in the tropics and sub-tropics and found mainly under cultivation for its pods and seeds. Leaves trifoliolate; flowers generally white; pods 5.0–7.5 cm. long and 1.8 cm. broad, flat, somewhat pubescent, with a very sharp beak; seeds rhomboidal, more than 1.20 cm. long, flat and thin, white, brown, red or speckled; when markings are present they radiate from the hilum.

The centre of origin of lima beans is considered to be in the region of Guatemala. Three lines of distribution are traced from this centre, viz. (*i*) the *Hopi branch* extending northwards to the United States of America and comprising mostly flat and medium-sized beans; (*ii*) the *Carib branch* carried to West Indies and Amazon basin, consisting mainly of oval or roundish beans, brightly red coloured and containing a high cyanide content; and (*iii*) the *Inca branch* radiating southwards to Peru, giving rise to large lima beans. The characteristic flavour of lima beans is due to a small amount of HCN present in them. Most of the types cultivated in India, Burma, Java and Mauritius are believed to be derived from the Carib branch, as indicated by their high cyanide content. All the three branches have contributed to the evolution of modern horticultural types, possibly due to field crossing by insects, not only within the group but also between groups, or by mutation. All evidence supports the conclusion that all of the many and diverse forms of the lima bean belong to a single species [Zukovskij, 24; Mackie, *Hilgardia*, 1943–44, **15**, 1; Yarnell, *Bot. Rev.*, 1965, **31**(3), 247].

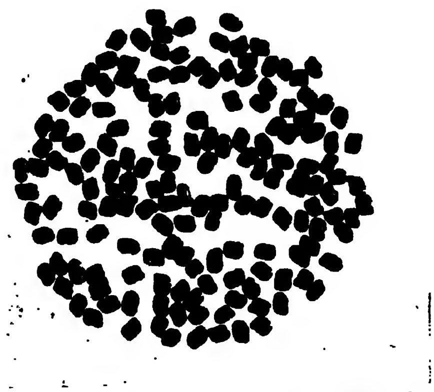

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FIG. 3—PHASEOLUS LATHYROIDES—SEEDS

There are two main groups, large-seeded Lima Beans and small-seeded Sieva Beans. According to Bailey, *P. lunatus* Linn. is the Sieva, Civet, Sewee or Carolina Bean, and *P. limensis* Macf. is the Lima Bean. Each of these groups includes tall growing pole types and dwarf bush forms. The bush forms are said to have originated as mutants or sports of tall pole types. On the basis of leaf and pod characters, five forms have been recognized. They are: forma *macrocarpus* (Flat Lima), forma *salicis* (Willow-leaved Lima), forma *lunonanus* (Bush Sieva), forma *limenanus* (Bush Lima), and forma *solanoides* (Potato Lima) (Yarnell, loc. cit.; Van Eseltine, *Tech. Bull. N.Y. St. agric. Exp. Sta.*, No. 182, 1931).

P. lunatus has been successfully crossed with *P. coccineus*. The cross between *P. lunatus* and *P. vulgaris* is successful only in the second generation (Yarnell, loc. cit.).

Cultivation—Though very widely grown in the tropics, the lima bean is much more sensitive to environment than many of the other cultivated species of *Phaseolus* and has consequently developed into a crop of primary importance only in certain countries. It requires a long growing season free from frost and a dry season during maturation of the seed. In India, it is a popular crop grown widely by home gardeners and as a market crop near urban centres. Some of the types grown in India are Double White (Butter Bean), Single White, Chocolate Brown (Sultani), Speckled, Florida Butter, Challenge, Hopi, Wilbur, Burpee Bush, Fordhook 242 and Henderson Bush (Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 216; Patel, *Poona agric. Coll. Mag.*, 1950–51, **41,** 211; Rahman *et al.*, *Curr. Sci.*, 1947, **16,** 351; Choudhury, 108).

FIG. 4—PHASEOLUS LUNATUS—FRUITING BRANCH

Lima beans are cultivated throughout India, particularly in Assam, West Bengal, Uttar Pradesh, Madras, Mysore, Maharashtra and Punjab. The crop requires a cool climate and a rainfall of 42.5–75.0 cm. It thrives well on fairly rich, loamy soil. Seeds are dibbled in July at the rate of 12 kg. per hectare; the distance between the seeds is kept at 1.2 m. in the line and about 1.8 m. between lines. The crop requires irrigation and heavy manuring except when it follows a heavily manured sugarcane crop. In the case of the trailing types (Pole Limas), bamboo supports are necessary, but the Bush Limas need no such support (Patel, loc. cit.; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 191; Pocha's Garden Guide, 133).

Diseases and Pests Lima beans are subject to dry root rot, anthracnose and rust. Downy mildew caused by *Macrophomina phaseoli* (Maubl.) Ashby is considered specific for all lima beans. The root rot of lima beans is a complex involving the fungi *Fusarium solani* f. *phaseoli* (Burkh.) Snyd. & Hans., *Pythium ultimum* Trow, *Rhizoctonia solani* Kuehn, *Thielviopsis basicola* (Berk. & Br.) Ferr. and *Macrophomina phaseoli* (Maubl.) Ashby. It is suggested that wireworms present in the soil may predispose the plants to root rot. Application of fumigants like dichloropropane-dichloropropylene mixture and ethylene dibromide solution and of insecticides like benzene hexachloride and DDT is said to reduce the incidence of root rot (Middleton *et al.*, *Phytopathology*, 1949, **32,** 813).

A yellow mosaic has been reported to be caused by a virus called the Double bean yellow mosaic virus. The disease is characterized by the appearance of bright yellow patches on the leaflets which may occasionally become completely chlorotic. Certain types are resistant to this disease (Capoor & Varma, *Curr. Sci.*, 1948, **17,** 152).

Utilization and Composition—Lima beans (seeds) are eaten fresh or after drying. They may also be fried in oil. Fresh beans when young are tender and sweet. The white forms are considered superior. Dried lima beans are boiled or baked for table use. In U.S.A., the beans are canned and frozen in large quantities (Brown, 1941, II, 142; Jacobs, II, 1275; Cruess, 236; Prabhakar *et al.*, *Food Sci.*, 1960, **9,** 307).

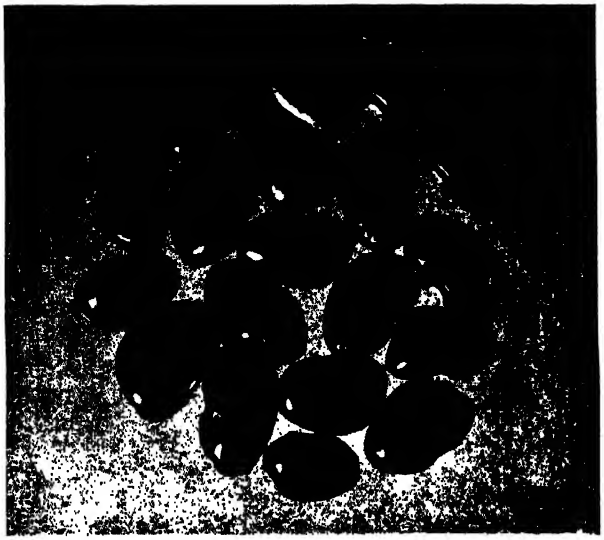

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FIG. 5—PHASEOLUS LUNATUS—SEEDS (CHOCOLATE BROWN)

The beans are rich in protein and contain a good amount of minerals. Analysis of the edible portion of green lima beans (from Philippines) gave the following values: moisture, 69.2 ; nitrogen, 1.3 ; ether extr., 0.3 ; crude fibre, 0.5 ; and ash, 1.5% ; calcium, 9 ; phosphorus, 97 ; iron, 1.3 ; carotene, 0.055 ; thiamine, 0.031 ; riboflavin, 0.093 ; nicotinic acid, 1.6 ; and ascorbic acid, 30.8 mg./100 g. A sample of dried ripe lima beans of a white-seeded type from Mysore contained: moisture, 13.3 ; albuminoids, 19.7 ; carbohydrates, 57.8 ; oil, 1.2 ; fibre, 4.3 ; and ash, 3.7%. Folic acid (0.034 mg./100 g., in green beans) and iodine (5 μg./100 g., dry basis) are reported to be present. The beans also contain a proteinase of the papain type, carotene oxidase, lecithin (0.62%), cephalin (0.09%), gum, and tannin. With maturity, there is an increase in the starch and protein and a decrease in sugar and ascorbic acid contents of the beans (Intengan *et al., Philipp. J. Sci.*, 1953, **82,** 227 ; *Agric. Ledger*, No. 2, 1905, 11 ; Sherman, 432 ; Iodine Content of Foods, 93 ; Jacobs, II, 1275 ; *Chem. Abstr.*, 1959, **53,** 22300 ; Wehmer, I, 580 ; Yamaguchi *et al., Food Res.*, 1954, **19,** 617).

The chief proteins of lima beans, like those of the other beans, are α-globulin (N, 15.55% ; S, 1.27%) and β-globulin (N, 14.81% ; S, 0.35%) ; a small quantity of an albumin is also present. The essential amino acid composition of the total proteins of lima beans is as follows (g./16 g. N): arginine, 6.1 ; histidine, 3.4 ; threonine, 4.7 ; phenylalanine, 6.2 ; methionine, 1.5 ; leucine, 8.3 ; *iso*leucine, 6.0 ; lysine, 5.9 ; tryptophan, 0.9 ; and valine, 7.8. Methionine is the limiting amino acid. The proteins of fresh, immature beans are reported to be superior in nutritive value to those of mature beans. The proteins in the raw beans have a low digestibility which can be improved by cooking ; at 10 per cent level of protein intake, the coefficient of digestibility in the raw and cooked beans was 34.0 per cent and 51.3 per cent respectively. The raw beans contain a highly concentrated trypsin inhibitor and a haemagglutinin both of which are destroyed by cooking or autoclaving ; the trypsin inhibitor retards growth of rats while the latter agglutinates human red blood cells (Jacobs, II, 1272–74 ; Altschul, 726, 308, 93 ; Kuppuswamy *et al.*, 36–37, 43 ; *Nutr. Abstr. Rev.*, 1949–50, **19,** 379 ; Huprikar & Sohonie, *J. sci. industr. Res.*, 1961, **20C,** 82).

The dry beans contain 1–2 per cent of a brown fatty oil having the following characteristics: sp. gr.$^{25°}$, 0.921 ; $n^{40°}$, 1.4772 ; solid. p., *c.* 1° ; sap. val., 189.3 ; iod. val., 99.8 ; titre of mixed fatty acids, 26° ; and unsapon. matter, *c.* 1% (Mensier, 445).

The green vines are used as fodder ; dehydrated vines contain 12.5 per cent protein. Silage prepared from the vines after the removal of the green pods is reported to be a satisfactory feed for dairy cows ; its nutritive value is as follows: dry matter, 27.3 ; protein, 3.3 ; dig. protein, 2.1 ; and total dig. nutrients, 14.2% ; nutritive ratio, 5.8. The vines are also made into hay (Miller, 30 ; Morrison, 325, 493, 1036).

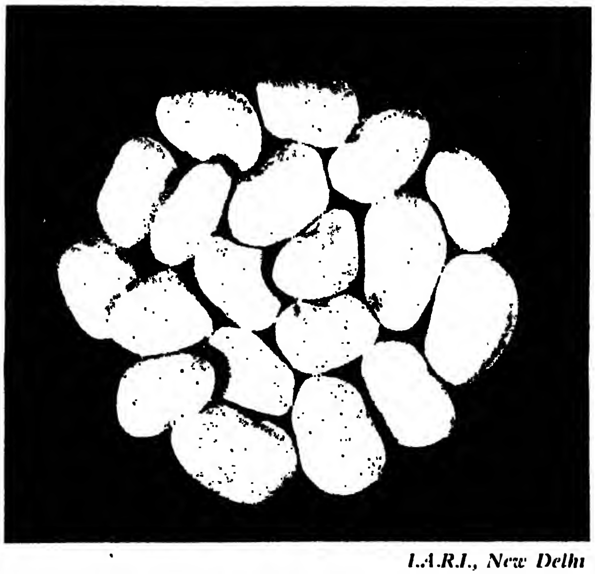

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FIG. 6—PHASEOLUS LUNATUS—SEEDS (WHITE)

Lima beans contain a cyanogenetic glucoside, named phaseolunatin (or linamarin, $C_{10}H_{17}O_6N$, m.p. 142°), and a specific enzyme which hydrolyses it under favourable conditions to glucose, acetone and hydrocyanic acid. The concentration of the glucoside varies widely in different samples; the amount of hydrocyanic acid liberated may vary from nil to 0.05 per cent or even higher. The dark coloured wild beans are believed to contain greater quantities of hydrocyanic acid (up to 970 p.p.m.) than the light coloured cultivated types. Up to 100 p.p.m. of HCN are considered as non-injurious to human beings. The amount of hydrocyanic acid released by some common Indian types is as follows: Double White (Butter Bean), 90–160: Single White, 100–300 (over 500 in some samples); Chocolate Brown (Sultani), 90–140: and the Speckled, 150–350 p.p.m. Roasting or boiling of the beans, particularly the large white types, removes the hydrocyanic acid from them almost completely, thus rendering them safe for human consumption. The bean flour can be detoxicated by moistening followed by drying. Lima beans have also been used to a large extent as cattle feed. Since they are generally fed in the raw state to animals, they should be used with caution for such purpose. Cases of poisoning have been reported due to the consumption of the beans and steps have been advocated to prohibit their import mainly from Burma (McIlroy, 22; Thorpe, VI, 91 : I, 659; Rahman *et al.*, *Curr. Sci.*, 1947, **16**, 351; Lander, 259–60).

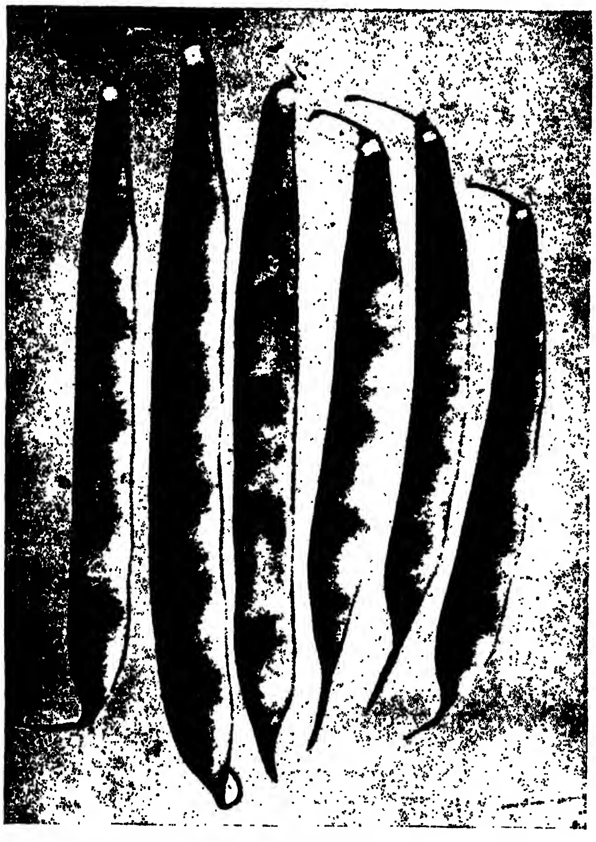

FIG. 7—PHASEOLUS VULGARIS—FRESH GREEN PODS

The leaves contain hydrocyanic acid (0.03–0.06%) and a new thiol, named phaseothione. The stems and pods are reported to be cyanogenetic (Wehmer, I, 580; Price, *Nature, Lond.*, 1957, **180**, 148).

The young seedlings are said to be eaten. In Malaya, the leaves are reported to be used in the form of a pulp to colour puddings green (Schery, 402; Burkill, II, 1709).

The plant has been used in Malaya as a cover crop of short duration and as green manure. The Maorese are said to make hay of it for use in the dry season (Whyte *et al.*, 304; Burkill, II, 1709).

The seeds are astringent and used as diet in fever. In Java, they are used medicinally in the form of a poultice applied to the abdomen for curing stomachache in small children (Chopra, Nayar & Chopra, 189; Burkill, II, 1709).

P. vulgaris Linn. syn. *P. nanus* Linn. FRENCH BEAN, DWARF BEAN, KIDNEY BEAN, HARICOT BEAN

D.E.P., VI(1), 194; Fl. Br. Ind., II, 200; Hector, II, 667.

HINDI—*Bakla, lobia, frash bean, rajmah* (seed); MAR.—*Shravanghevda*; GUJ.—*Phanasi*; TEL.—*Barigalu*; KAN.—*Tingalavari*.

PUNJAB—*Babri*.

A sub-erect or twining annual, native of tropical America and now grown extensively throughout the warm regions of the world. Leaves trifoliolate; flowers white to violet-purple; pods slender, 10–26 cm. long, straight or slightly curved, sides convex or rounded, surface glabrous or faintly pubescent, beak prominent; seeds more or less kidney shaped, elongated or nearly globular or somewhat compressed, white, red, purple, blackish or mottled.

The French bean is reported to have its primary origin in southern Mexico and Central America and a secondary origin in the Peruvian-Ecuadorian-Bolivian area. It is considered to have arisen through a series of recessive mutations. A climbing annual wild bean, *P. aborigineus* Burkart, found in northern Argentina has been crossed with *P. vulgaris*. It is concluded that the French bean has been

derived from the former (Yarnell, *Bot. Rev.*, 1965, **31,** 247).

French bean is grown almost throughout India for its green pods. It thrives best in a relatively warm and humid weather. The hilly tracts are more suitable for its cultivation in the summer months since temperatures in the plains are too high (Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 138 ; Purewal, 46).

Varieties of French beans have been classified variously, some based on morphological characters of the plant, pod and seeds, while others are based on their mode of use. Some important characteristics mentioned are: plants bushy or trailing ; pods flat or rounded, curved or straight, brittle or stringy ; seeds white, coloured or mottled, uniform, rounded or flat, big or small. Amongst these, the seed colour, shape and size are given a prominent place (Tracy, *Bull. U.S. Bur. Pl. Ind.*, No. 109, 1907 ; Steinmetz & Arny, *J. agric. Res.*, 1932, **45,** 1 ; Thompson & Kelly, 444).

The characteristics of some of the French bean types reported to be grown in India are given in Table 1. In addition, there are reports of new varieties from Hungary under trial in the Nilgiris. Some of the other types reported to be grown in India are: Dwarf Dutch, Mont d'Or, Dwarf Algerian, Dwarf Yellow, Canadian, New Golden Wax, White Sword, White Predane, Princess Runner, Broad Pod Kidney and Contender (Pocha's Garden Guide, 132 ; Pal *et al., Indian J. Hort.*, 1956, **13,** 67 ; Sampson, loc. cit. ; Woodrow, 267 ; Purewal, 46).

Cultivation—French bean is grown on all kinds of soil, but does best on loam. A very rich soil is avoided as it leads to excessive vegetative growth at the expense of fruiting. Only a single crop is raised annually but as the pods are ready within two months, sowing is usually done in succession, at intervals of a fortnight each, to ensure a steady supply. In the plains, beans are sown from the middle of August to the end of October or earlier in June–July if the weather is not too hot and the rains not too heavy. On the hills sowing is done from the end of March to the end of June.

The land is prepared by adding about 40 cartloads of manure per hectare and giving 2–3 ploughings. The soil is well pulverized and the surface made smooth. Seeds are sown thinly in rows about 45–60 cm. apart, at a distance of 7.5–10.0 cm. in the rows. Seed rate is about 67 kg. per hectare. As the plants come up, cultivation is given frequently during the entire season of growth in order to keep the crop free of weeds ; the crop is irrigated about once a week when the weather is dry (Purewal, 46 ; Pocha's Garden Guide, 132).

TABLE 1—CHARACTERISTICS OF IMPORTANT FRENCH BEAN TYPES GROWN IN INDIA*

Type	Botanical characters	Agricultural characters
Plentiful	Bush variety	..
Black Prince	do.	..
Giant Stringless Green Pod	Bush variety ; pods very long, scimitar-shaped, sharply constricted between seeds ; stringless ; seeds truncate or rounded at ends, brownish in colour	..
Kentucky Wonder	Trailing variety ; pods very long, scimitar-shaped, slightly stringy, without fibre ; seeds long, rounded or truncate at ends ; solid chamois in colour fading to dark fawn	
No. 34 A	Trailing variety growing luxuriantly ; pods green, long, flat ; seeds white	Early variety maturing in 6-7 weeks ; yield 6,720 kg./ha. Suitable for Poona, Belgaum and Ahmadnagar districts
Pencil Pod (No. 58)	Plant of medium stature ; pods light green, long, round fleshy, tender and sweet ; seeds chocolate-coloured	Early variety maturing in 6 weeks ; yield about 4,480 kg./ha. Suitable for Ahmadnagar and Belgaum districts
Contender	Bush variety with vigorous growth ; pods of both large and small size ; the former with an off-round shape and the latter with oval shape	A high yielder, widely adapted ; resistant to bean mosaic
No. 4 Open	Bush variety ; pods yellow, medium in length, smooth, tender and very sweet	Early variety ready for harvest in 5 weeks ; yield about 2,240 kg./ha. Suitable for Poona, Belgaum and Ahmadnagar districts

* Tracy, *Bull. U.S. Bur. Pl. Ind.*, No. 109, 1907 ; Kohle, *Poona agric. Coll. Mag.*, 1961-62, **52**(1 & 2), 17 ; Singh *et al., Indian J. Hort.*, 1964, **21,** 221 ; *Bull. Minist. Agric., Lond.*, No. 87, 1962, 4–5 ; Zaumeyer, *Fmrs' Bull., U.S. Dep. Agric.*, No. 1915, 1957 ; Hills *et al., Bull. Fla agric. Exp. Sta.*, No. 530, 1953.

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FIG. 8—PHASEOLUS VULGARIS—SEEDS OF DIFFERENT TYPES

Diseases—French bean is subject to diseases such as anthracnose (often called rust), mosaic, dry rot, etc. Anthracnose is caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. attacking the leaves, stems, pods and seeds. Cankers are found on the stems and leaf veins; rounded or irregular sunken spots are formed on the pods. In severe cases, the pods may be completely covered with spots and no seed is produced. Rains increase the severity of anthracnose disease. Roguing of diseased plants, use of disease free seed or growing anthracnose resistant varieties is advised (Krishnamurthi, 97-98; Venkata Rao, *Madras agric. J.*, 1955, **42**, 104).

A leaf-spot disease has been recorded from the Nilgiris. Dark brown spots of varying sizes and shapes appear on the leaves. The causal organism is identified as *Isariopsis griseola* Sacc. (Srinivasan, *Curr. Sci.*, 1953, **22**, 20).

Several other fungal diseases have been recorded on French beans. They are leaf blotch caused by *Ascochyta phaseolorum* Sacc., and rust caused by *Uromyces appendiculatus* (Pers.) Link (*Indian J. agric. Sci.*, 1950, **20**, 107; Butler, Bisby & Vasudeva, 213, 256, 116).

Pests—French bean is subject to the attack of many insects, the most important of them being the epilachna beetle, flea beetle, aphids, etc. Epilachna beetle (*Epilachna vigintioctopunctata* Fabr.) is one of the worst enemies of French bean. The adult breeds and the immature grubs feed upon the epidermis of the leaves, resulting in the drying and falling of the attacked foliage. The insect can be controlled by spraying with rotenone, parathion, malathion or cryolite (Ahmed & Alam, *Pakist. J. Sci.*, 1960, **12**, 195; Thompson & Kelly, 450–51).

The flea beetle (*Longitarsus belgaumensis*) attacks the bean plants within a day of germination. The leaves become marked with shot holes and are thus deprived of effective foliar surface for photosynthetic activity. Soaking the seeds in systox solution before sowing has been found to keep down the pest (Ramasubbaiah & Krishnamoorthy, *Andhra agric. J.*, 1961, **8**, 190).

The root portions of French bean plants are attacked by the aphid, *Smynthurodes betae* Westw.= *Trifidaphis phaseoli* (Pass). The aphids cluster round the roots. The plants get stunted (Channa Basavanna, *Mysore agric. J.*, 1958, **33**, 220).

A bean fly (*Melanagromyza phaseoli* Coq.) has been found to cause considerable damage to French beans. The general symptoms of the attack are the

drooping and withering of leaves and finally the wilting of the plant. Nicotine sulphate and DDT are reported to be effective in reducing infestation (Reddy, *Curr. Sci.*, 1961, **30,** 192).

Harvesting and Yield—Flowering in French bean starts 40–45 days after sowing and a week later pods begin to appear. Beans are harvested for the table before the constrictions on the pods become evident. The pods are picked by hand at intervals of a few days and 4–6 pickings are taken. It is most important to keep the plants closely picked since failure to do this will result in the plants going out of bearing and will reduce the yield considerably. The yield of green pods is 4,480–5,600 kg. per hectare (Purewal, 46; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 191).

Before marketing, the broken and the diseased pods, leaves and butts of stem are removed. Pre-packaging in consumer size polythene bags with 1.17 per cent aeration and storing at room temperature and at 80–85 per cent R.H. increased the shelf life of French beans from 3 days to 6–7 days (Purewal, 46; Anandaswamy & Iyengar, *Food Sci.*, 1961, **10,** 279).

Utilization and Composition

French beans are mainly used as a vegetable in the unshelled condition or as a pulse in the shelled condition. The pods which are discoloured or otherwise unsuited for human consumption are fed to livestock. Bean straw is also used as an animal feed (Hill, 338; Morrison, 325).

The edible portion (94%) of the green tender pods contain: moisture, 91.4; protein, 1.7; fat, 0.1; carbohydrates, 4.5; fibre, 1.8; and mineral matter, 0.5%; calcium, 50; magnesium, 29; phosphorus, 28; iron, 1.7; ionisable iron, 1.0; sodium, 4.3; potassium, 120; copper, 0.2; sulphur, 37; and chlorine, 10 mg./100 g. The vitamin contents are as follows: vitamin A, 221 I.U.; thiamine, 0.08; riboflavin, 0.06; nicotinic acid, 0.30; and vitamin C, 14 mg./100 g. The pods also contain pectic substances (as calcium pectate, 9–15%, dry basis, depending on pod length), oxalic acid (0.03%), mannitol and sugars including glucose and fructose (1.16%). The following free amino acids have been identified in the vegetable: alanine, glutamic acid, valine, tyrosine, phenylalanine, aspartic acid, glutamine, serine, glycine, threonine, γ-aminobutyric acid, pipecolic acid, methionine, leucines and traces of cystine and lysine. With the maturity of pods, the contents of carotene, thiamine and riboflavin decrease while those of niacin, ascorbic acid, calcium, phosphorus and protein are found to increase [Nutritive Value of Indian Foods, 61, 97, 128; Kertesz, 294–96; Wehmer, I, 576; Sah & Gupta, *Agra Univ. J. Res.* (*Sci.*), 1960, **9,** 191; Rao *et al.*, *J. sci. industr. Res.*, 1956, **15C,** 39; Jacobs, II, 1261–65].

Large quantities of green tender pods are preserved in U.S.A. by freezing and canning. Frozen pods are more palatable and have a better colour than canned pods. For freezing, the pods are blanched in live steam or boiling water for 2 to 2.5 minutes, after the strings and ends are cut. They are then frozen rapidly and packed in containers and stored at $-18°$ to $-23°$. For canning, the pods should be deep green, crisp and tender and as free from fibre and strings as possible. The pods are snipped by hand or machine, graded into various sizes, blanched in hot water at 85–88° or steam for 1.5 to 2 minutes and then canned in 2 per cent brine. There is a considerable loss of vitamins during freezing or canning, the loss of ascorbic acid being particularly heavy (Jacobs, II, 1270; Cruess, 812–15, 229–33; *Nutr. Abstr. Rev.*, 1949–50, **19,** 836; Dhopeshwarkar & Magar, *J. sci. industr. Res.*, 1954, **13B,** 849; *Chem. Abstr.*, 1951, **45,** 1699).

The beans (seeds) can be used after drying in the same way as other pulses. Dried beans commonly marketed under the name *Rajmah* are used in the same way as cowpea and gram. They are consumed after cooking and mixing with salt and condiments. Beans share with peas the virtue of being among the most nutritious of the vegetable crops. They contain high percentages of both proteins and carbohydrates and rank high in calorific value. They compare closely with meat as a source of protein. Owing to the nature of their protein content, beans require cooking to improve their digestibility. Beans are best suited for manual workers or for growing children, but should be eaten in moderation by persons who lead sedentary lives.

Analysis of a market sample of *Rajmah* gave the following values: moisture, 12.0; protein, 22.9; fat, 1.3; carbohydrates, 60.6; and minerals 3.2%; calcium, 260; phosphorus, 410; and iron, 5.8 mg.; calorific val., 346 cal./100 g. The vitamin contents of the beans are: thiamine, 0.6; riboflavin, 0.2; nicotinic acid, 2.5; and ascorbic acid, 2.0 mg./100 g. The mineral composition of the beans from another source was as follows: sodium, 43.2; potassium, 1,160; calcium, 180; magnesium, 183; iron, 6.65; copper, 0.61; phosphorus, 309; sulphur, 166; and

chlorine, 1.8 mg./100 g. The beans contain also iodine (1.4 μg./100 g.), manganese (1.82 mg./100 g.), and arsenic (0.03 mg./100 g.). The carbohydrate constituents of the beans are: sugars, 1.6; dextrins, 3.7; starch, 35.2; pentosans, 8.4; galactans, 1.3; and cellulose, 3.1%. Pectic substances (0.7%) are also present. Among the miscellaneous substances in the bean are "phaseothione", traces of hydrocyanic acid, allantoin, allantoic acid and the enzymes catalase, succinic dehydrogenase, phosphatase, allantoinase and uricase (Nutritive Value of Indian Foods, 53, 89; Wu Leung *et al.*, *Agric. Handb. U.S. Dep. Agric.*, No. 34, 1952, 29; McCance & Widdowson, 85; Iodine Content of Foods, 92; *Chem. Abstr.*, 1949, **43,** 9289; Kertesz, 294–96; Price, *Nature, Lond.*, 1957, **180,** 148; Wokes & Willimott, *J. Pharm., Lond.*, 1951, **3,** 905; Jacobs, II, 1269–70; *Chem. Abstr.*, 1951, **45,** 2542; 1957, **51,** 9805).

The proteins of the beans comprise two globulins, phaseolin (N, 16.5%; S, 0.5%) and conphaseolin (N, 15.7%; S, 1.4%), and an albumin, phaselin (N, 14.4%; S, 0.5%). More recently, a crystalline substance having the properties of a protein and amounting to about 16 per cent of the total nitrogenous material has been reported. Peptides, free amino acids and amides are also present. *l*-S-Methyl-*l*-cysteine and γ-glutamyl-S-methyl-cysteine, a compound closely related to glutathione have been isolated from the beans. Phaseolin which is the principal protein of the beans has the following nitrogen distribution: ammonia N, 10.4; humin N, 2.05; basic N, 22.3; and nonbasic N, 65.2% of the total nitrogen. The essential amino acid composition of the bean proteins is as follows (g./16 g. N): arginine, 9.4; histidine, 3.0; lysine, 6.4; tryptophan, 0.5; phenylalanine, 3.4; methionine, 3.9; threonine, 3.2; leucine, 8.2; *iso*leucine, 5.8; and valine, 6.0. The proteins are deficient in methionine [Thorpe, I, 659; Bourdillon, *J. biol. Chem.*, 1949, **180,** 553; Powrie, *J. agric. Fd Chem.*, 1961, **9,** 67; Thompson *et al.*, *Nature, Lond.*, 1956, **178,** 593; *Agric. Res., Wash.*, 1957–58, **6**(7), 15; Allen, IX, 15; Kuppuswamy *et al.*, 48, 35].

The proteins in the raw beans have low digestibility and biological values. This has been attributed to the presence of heat-labile trypsin or proteolytic inhibitors which interfere with the utilization of the proteins. Heat processing destroys the inhibitors and the cooked beans have a better growth promoting value; digestibility co-efficients of the proteins at 10 per cent level of intake in the raw and cooked beans have been found to be 56 per cent and 79.5 per cent respectively. The beans contain also factors which possess agglutinating and toxic properties. A toxic compound, named phaseolotoxin A (N content, 13.5%) has been separated; it has intraperitoneal L.D.$_{50}$ of 55 mg./kg. in the mouse and shows also oral toxicity and interferes with the intestinal absorption of food. A fraction B having weaker haemagglutinating activity than A is also present in the beans. The haemagglutinating activity is stated to be lost on autoclaving the beans. Presence of a toxic protein which loses its toxicity when the beans are cooked is also reported (Sohonie & Bhandarkar, *J. sci. industr. Res.*, 1955, **14C,** 100; Rajagopalan *et al.*, *Sci. & Cult.*, 1949–50, **15,** 444; Kuppuswamy *et al.*, 37, 42; *Chem. Abstr.*, 1957, **51,** 5937; 1961, **55,** 10607, 12558; Huprikar & Sohonie, *J. sci. industr. Res.*, 1961, **20C,** 82).

The beans contain 1–2 per cent of a golden yellow fatty oil having the following characteristics: sp. gr.$^{15.5°}$, 0.9603; $n_D^{30°}$, 1.4808; sap. val., 132.6; iod. val., 149.8; acid val., 20.5; R.M. val., 1.0; Polenske val., 2.0; and unsapon. matter, 7.0%. The oil contains 19 per cent of saturated (palmitic and a small amount of carnaubic) and 63.3 per cent of unsaturated (oleic, linoleic and linolenic) fatty acids (Mensier, 446; *Chem. Abstr.*, 1940, **34,** 654).

The straw from the plant can be fed to cattle, sheep and horses. It is satisfactory as a part of the roughage when fed with good hay and is comparable to corn or sorghum fodder in nutritive value. Analysis of a sample gave the following values: moisture, 10.9; protein, 6.1; fat, 1.4; N-free extr., 34.1; fibre, 40.1; ash, 7.4; calcium, 1.7; phosphorus, 0.1; potassium, 1.0; dig. protein, 3.0; and total dig. nutrients, 45.2%; nutritive ratio, 14.1. Silage may be prepared from green vines after removal of the pods. Dehydrated bean vine meal prepared from the green plant after the removal of pods is comparable to lucerne meal as a vitamin supplement for chicks. It contains protein 18.3; dig. protein, 12.3; and total dig. nutrients, 46.3%; nutritive ratio, 2.8. Meal made from vines with mature leaves is inferior in quality (Morrison, 325, 331, 1002).

In Java, the young leaves are eaten as a salad. Leaves contain carotene (178.8 mg./100 g.), thiamine, riboflavin, nicotinic acid, folic acid and pantothenic acid. They contain also a quercetin glycoside. The roots are reported to cause giddiness in human beings and animals (Burkill, II, 1711; Palmer, 249; *Nutr. Abstr. Rev.*, 1953, **23,** 775; Marsh, *Nature, Lond.*,

1955, **176**, 176; Godbole, *Poona agric. Coll. Mag.*, 1959–60, **50**, 91).

The green pod shells are reported to contain traces of a cyanogenetic glycoside, and an unidentified substance which reduces the blood sugar level. They are useful as a diuretic, especially in kidney and heart ailments and as an adjuvant in mild cases of diarrhoea (Hoppe, 660–61).

P. atropurpureus Moc. & Sesse emend. Hassler (HINDI—*Siratro*), a native of Mexico and tropical America, shows considerable variations and includes a number of varieties and forms. This tropical perennial pasture legume has a strong, stoloniferous habit with a long, strong tap root and has been introduced into Rajasthan where it has shown considerable promise as a drought resistant fodder legume. It can stand hard and frequent grazing [Hassler, *Candollea*, 1922 24, **1**, 417; Patil *et al.*, *Indian Fmg*, *N.S.*, 1967–68, **17**(1), 36].

PHAULOPSIS Willd. (*Acanthaceae*)

A small genus of herbs distributed in India, Africa and Mascarene Islands. One species occurs in India.

P. dorsiflora (Retz.) Santapau syn. *P. parviflora* Willd., C. B. Clarke (Fl. Br. Ind.) in part; *Micranthus oppositifolius* Wendl.

Fl. Br. Ind., IV, 417; Santapau, *Bot. Mem., Univ. Bombay*, No. 2, 1951, 29.

BOMBAY—*Waiti, ran-maushi.*

A much-branched diffuse or often prostrate perennial herb found throughout India excepting north-western region and ascending up to 900 m. in the hills. Leaves ovate, entire or subcrenate; flowers white, in spikes; capsules long, clavate; seeds orbicular, dark brown, hairy.

The plant, dried and pulverized, is used as a dressing for wounds. Fresh juice of the plant is applied to sores (Dalziel, 452).

Pheasants — *see* **Birds**

PHILADELPHUS Linn. (*Saxifragaceae*)

D.E.P., VI(1), 197; Fl. Br. Ind., II, 407.

A genus of shrubs distributed in Asia, Europe and North America. Several species, their cultivars and hybrids are grown in gardens for their showy fragrant flowers. Three species are reported to occur in India.

P. coronarius Linn. (MOCK ORANGE), a native of Europe, is a hardy ornamental shrub with creamy white fragrant flowers, grown in gardens at higher altitudes on the hills. It can be propagated by cuttings, suckers or layers. The flowers contain an essential oil. On extraction they give (0.14–0.18%) a concrete yielding 25.0–27.2 per cent of an absolute having a penetrating fruity odour; they also contain small amounts of a wax. The flowers are reported to be used in homoeopathy (Collett, 180; Firminger, 532; Gopalaswamiengar, 283; Wehmer, I, 428; Guenther, V, 407; *Chem. Abstr.*, 1950, **44**, 553; Hoppe, 662).

P. tomentosus Wall. ex G. Don syn. *P. coronarius* var. *tomentosus* C.B. Clarke (Fl. Br. Ind.) is a shrub, up to 3.5 m. high, with ovate-lanceolate leaves and white fragrant flowers, found throughout the Himalayas at altitudes of 1,500–3,000 m. It has been reported to be used for making ropes.

PHLEUM Linn. (*Gramineae*)

A small genus of annual or perennial grasses of temperate zone. Five species occur in India, including the introduced species, *P. pratense*.

P. pratense Linn. TIMOTHY GRASS

D.E.P., VI(1), 197; Fl. Br. Ind., VII, 236; Hubbard, 297.

A medium-sized, tufted perennial grass, indigenous in Europe and temperate Asia and extensively cultivated as a pasture grass in most countries including India. In India, it has been found growing in the Himalayas, on the hills near Simla, and also in Shillong, where it has been found as an escape. Culms erect, 0.4–1.5 m. tall; basal nodes swollen or bulbous; leaves up to 20 cm. long and 4–8 mm. wide; panicle cylindrical, spikelets densely crowded; caryopsis spherical-ovoid in shape.

Timothy is an important fodder grown for hay, pasture or silage; it is also adapted for soil conservation and improvement and crop rotation. It includes numerous strains which vary considerably in growth and value to the farmer. Some are more suitable for hay than for pasture. It is shallow rooted and grows best on moist heavy soils; it is hardy and is widely grown in cold countries. It cannot stand drought (Ahlgren, 171; Hubbard, 297; *World Crops*, 1958, **10**, 245).

Timothy is usually grown in mixture with clover or alfalfa, the seed rate being 6 to 14 kg. per hectare in mixture with clover. It gives a large yield of about 980 kg. of green matter per hectare. Considerably greater yields are obtained by the mixture of timothy and clover. The yield decreases with the age, and the grass needs manuring with fertilizers. For hay it

should be cut before flowering (Morrison, 363; Whyte *et al.*, 1959, 363; Ahlgren, 180; *Chem. Abstr.*, 1938, **32,** 7154).

Timothy is a highly palatable and nutritious grass. At early stages of growth, timothy pasture is relished by stock. Analysis of the young green forage gave the following values: moisture, 76.1; protein, 4.7; fat, 0.9; carbohydrates, 11.1; fibre, 4.6; ash, 2.6; calcium, 0.14; phosphorus, 0.09; potassium, 0.50; dig. protein, 3.5; and total dig. nutrients, 16.5%; nutritive ratio, 3.7. Timothy proteins are rich in tryptophan, lysine and valine contents. The grass is reported to contain traces of an alkaloid (Morrison, 363-65, 1034, 1098, 1106; *Yearb. Agric., U.S. Dep. Agric.*, 1948, 685; Kuppuswamy *et al.*, 226; Watson, 43; *Chem. Abstr.*, 1942, **36,** 608).

Timothy can be easily cured into a bright, clean hay free from dust and mould. Hay made from the grass cut at not later than early bloom stage is suitable for dairy cows, beef cattle and sheep. Hay cut in full bloom is preferable for feeding work horses and mules and is taken as a standard with which other hays are compared; early cut hay may be too laxative for these animals. Timothy hay, cut before bloom, gave the following values: moisture, 11.0; protein, 9.7; fat, 2.7; N-free extr., 42.2; fibre, 27.9; mineral matter, 6.5; dig. protein, 6.1; and total dig. nutrients, 56.6%; nutritive ratio, 8.3. Timothy can be made into a silage very palatable to dairy cattle and good in carotene content (2–4 mg./100 g.). Nutritive value of the wilted timothy silage is as follows: moisture, 59.2; protein, 4.4; dig. protein, 2.2; and total dig. nutrients, 23.5%; nutritive ratio, 9.7 (Morrison, 363–65, 1016, 1042; *Chem. Abstr.*, 1938, **32,** 7154; 1940, **34,** 6694).

Stored, sterile extracts from timothy arrested the growth of *Sarcoma-45* and other strains: fresh extracts were ineffective. The stem of the plant inhibits the growth of *Sphacelia segetum*. Two allergins (probably low molecular weight proteins) producing strong skin reactions and a haemagglutinating action, and similar in their specificity and properties have been isolated from timothy pollen (*Chem. Abstr.*, 1957, **51,** 3029; 1961, **55,** 5647; 1962, **56,** 14798; 1960, **54,** 22996).

Timothy can be used for the extraction of chlorophyll (Hoppe, 662).

P. arenarium Linn., *P. commutatum* Gaudich. syn. *P. alpinum* auct. non Linn. and *P. paniculatum* Huds. syn. *P. asperum* Jacq. are found in western Himalayas, Kashmir and Punjab at altitudes of 1,500–2,700 m. Analysis of the grasses from Kashmir gave the following values (dry matter basis): *P. commutatum*—protein, 8.64; ether extr., 1.84; carbohydrates, 47.42; crude fibre, 34.67; mineral matter, 6.53; calcium (CaO), 0.46; and phosphorus (P_2O_5), 0.44%; *P. paniculatum*—protein, 11.37; ether extr., 2.67; carbohydrates, 40.22; crude fibre, 30.18; mineral matter, 13.93; calcium (CaO), 0.85; and phosphorus (P_2O_5), 0.77% (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26,** 415).

PHLOGACANTHUS Nees (*Acanthaceae*)

A small genus of herbs or subshrubs distributed in Indo-Malaysian region. About ten species occur in India.

P. thyrsiflorus Nees

D.E.P., VI(1), 198; Fl. Br. Ind., IV, 512.

ASSAM—*Banheka, titabahak, titaphul;* GARO—*Ellot;* KHASI—*Baskabomphang, dieng-soh-ja-buid, dieng-soh-kajut;* MIKIR—*Jaogan, rambha arong;* NEPAL—*Chua;* LEPCHA—*Rheeom;* KUMAUN—*Kaldona, Kawadoni.*

An evergreen shrub, 0.9–3.6 m. high, found in the sub-tropical Himalayas from the Ravi to Bhutan, upper Gangetic plain, Bihar, North Bengal and plains and hills of Assam at an altitude of 1,200 m. Leaves drooping, elliptic-lanceolate; flowers orange coloured or brick red, in long thyrsoid panicles; capsules subquadrangular with 12–14 seeds.

The plant occurs as an undergrowth in moist, shady places in parts of the sub-Himalayan region and in sal forests of Assam; it is gregarious and kills the vegetation beneath it. It is often cultivated as an ornamental plant for its handsome, laurel-like foliage and long spikes of flowers. It is also useful for shrubbery. It can be propagated by cuttings in the rainy season (Troup, II, 694; Bor, 332; Gopalaswamiengar, 283).

The flowers are eaten cooked as a vegetable. Fruits and leaves are taken after burning as a specific for fevers. In Punjab, the plant is put to the same medicinal uses as *Adhatoda vasica* (Fl. Assam, III, 443; Kirt. & Basu, III, 1890).

Wood (wt., 592.74 kg./cu.m.) is white, moderately hard and close-grained.

P. jenkinsii C. B. Clarke (LAKHIMPUR—*Tita gachh, titaphul*) is a shrub with elliptic-acute, sub-entire leaves and red flowers found in Assam. The plant is commonly planted as a hedge around dwellings. It is propagated by cuttings. A decoction of leaves is given

FIG. 9—PHLOGACANTHUS THYRSIFLORUS—FLOWERING BRANCH

for diseases of spleen and liver and for fevers [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 413].

P. tubiflorus Nees (ASSAM—*Bhataitita*; MIKIR—*Banchha, banchok*; LUSHAI—*Vatezuk*) is a shrub, 1.8–2.4 m. high, with elliptic or ovate-acuminate, entire, sub-entire or obscurely crenulate leaves and red flowers found in Assam and Khasi and Garo hills up to an altitude of 900 m. Flowers of the plant are eaten cooked as a vegetable. Leaves yield a lather on rubbing with water and are used for washing purposes (Fl. Assam, III, 444).

Phlogopite — *see* **Mica**

PHOEBE Nees (*Lauraceae*)

A genus of evergreen trees or shrubs distributed in the Indo-Malaysian region, Pacific Islands, tropical America and West Indies. About nine species occur in India.

Some of the North-East Indian species of *Phoebe*, especially *P. goalparensis*, *P. hainesiana*, *P. cooperiana* and *P. attenuata*, yield excellent light-weight timbers, almost indistinguishable from one another and constitute one of the most valuable timbers of Assam, known as BONSUM in trade. The sapwood of bonsum is greyish white; heartwood pale greenish buff when freshly sawn, changing quickly to rich brown resembling teak (hence sometimes called Assam Teak), interlocked-grained, fairly even or coarse-textured, soft, moderately strong and light. Bonsum can be air-seasoned well with care: green conversion and stacking under cover with good air circulation have been recommended. It can also be kiln-seasoned without difficulty: 2.5 cm. thick planks take 8–10 days to season: in addition to the initial steaming, it requires one intermediate steaming and another towards the end for 2–3 hours at 55° and 100% R.H. Once properly seasoned, bonsum is a very steady wood. It is easy to saw and work and finishes to a fine smooth surface. Though not very ornamental, it looks well under a wax polish. It is only moderately durable and is easily treatable under open tank process. It should not be used in outdoor positions without suitable preservative treatment (Trotter, 1944, 147–48; Bor, 56; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 56; Rehman, *Indian For.*, 1953, **79**, 369; Masani, ibid., 1953, **79**, 229).

Bonsum is used for house construction, door and window frames, veneers, plywood, packing cases, cabinet-making, interior fittings of railway coaches, furniture, general joinery, pattern-making, and in aircraft construction [Trotter, 1944, 148; Limaye, loc. cit.; IS: 399, 1952, 14, 16, 18; *J. Timb. Dryers' & Pres. Ass. India*, 1956, **2**(1), 22; **2**(3), 15].

P. attenuata Nees

Fl. Br. Ind., V, 143.

EASTERN HIMALAYAS—*Angare, aule lapche kawla*; ASSAM—*Bonsum, thi-jing-phang, thing-batwang-arong*.

A medium- to large-sized tree, up to 33 m. in height, found in the eastern Himalayas and hills of Assam, up to an altitude of 1,200 m. Bark dark grey, exfoliating in papery flakes; leaves oblong or oblanceolate, crowded at the ends of branchlets, coriaceous; flowers in spreading panicles; fruit narrowly ellipsoid.

The tree is a shade bearer and cannot stand direct exposure in young stages. Natural regeneration by seeds takes place profusely even under low cover, provided there is no competition from weeds. Artificial regeneration can be done by transplanting nursery-raised seedlings: seeds are sown, immediately after collection in May–June, in shaded beds. Transplantation is done in June during the second rainy season, when the seedlings are c. 20 cm. high;

winter transplanting has also given encouraging results. Raising the plants in lines, under the shade of *Tephrosia candida* DC. or a fast growing light demander like *Terminalia myriocarpa* Heurck & Muell. Arg., has been recommended; a spacing of 1.8 m. × 1.8 m. is considered suitable (Troup, III, 789; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 93).

The wood cannot be differentiated from that of *P. goalparensis* and is put to the same uses; it is especially prized for cabinet-work. It is a medium quality fuelwood (Fl. Assam, IV, 73; Bor, 56; *Indian For.*, 1948, **74,** 279; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

P. cooperiana U. N. Kanjilal ex A. Das

Fl. Assam, IV, 75; Das, *Ann. R. bot. Gdn Calcutta, 150th Anniv. Vol.*, 1942, 149, Fig.

N.E.F.A.—*Mekahi.*

A large tree, up to 36 m. in height and 4.2 m. in girth, found in N.E.F.A. and Darrang in Assam. Bark greyish, exfoliating in flakes; leaves obovate to oblong-lanceolate; flowers in panicles, grey; fruit ellipsoid, blackish.

The wood resembles that of *P. goalparensis* and is put to the same uses. It is, however, reported to be very refractory to treatment (Pande *et al., Indian For. Bull., N.S.*, No. 208, 1956, 5).

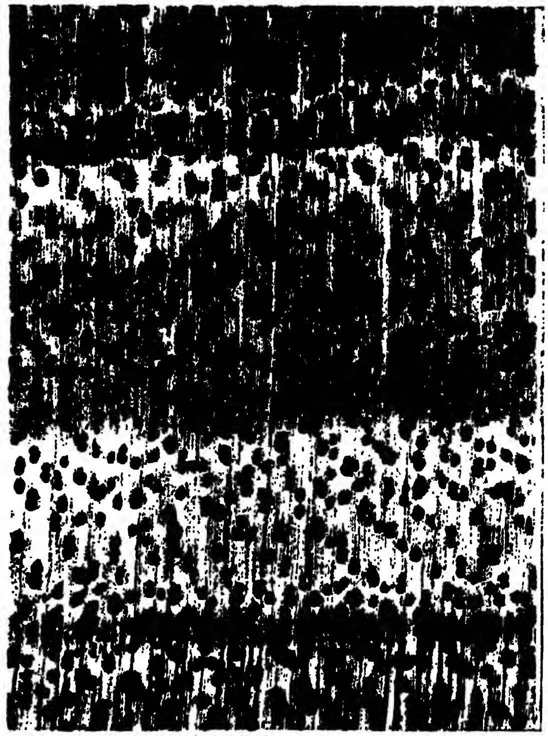
***P. goalparensis** Hutchins.

Fl. Assam, IV, 73.

Assam—*Bonsum, nikahi.*

A large tree, buttressed at the base, found in Assam. Bark grey, reticulately furrowed; leaves obovate or ovate-lanceolate; flowers in lax panicles; fruit ellipsoid, blackish.

P. goalparensis is a shade bearer and cannot stand direct exposure in early stages. Artificial reproduction is done by seedlings raised in shaded beds in the nursery. Transplanting may be done in June, when the seedlings are 8 months old and *c.* 23 cm. high, in between the lines of *Tephrosia candida* DC. Winter transplanting of at least 1.2 m. high plants with all the branches and leaves pruned off and the use of *Lagerstroemia speciosa* as a cover crop have given better results, as this minimizes competition by weeds, which would otherwise smother smaller transplants after the death of *Tephrosia*. Transplanting without initial line-sowing technique, with a spacing



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 10—PHOEBE GOALPARENSIS—TRANSVERSE SECTION OF WOOD (×10)

of *c.* 7 m. has been recommended. Stump planting has also given encouraging results. Direct sowing has been found unsatisfactory. *P. goalparensis* is susceptible to mottled spongy rot [*Ganoderma applanatum* (Pers.) Pat.], brownish pocket rot (*Polyporus gilvus* Schw.), white spongy rot [*Trametes corrugata* (Pers.) Bres.] and white fibrous rot (*T. serpens* Fr.) (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 95; Jacob, *Indian For.*, 1952, **78,** 602; Kadambi & Dabral, ibid., 1955, **81,** 129; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1,** 275).

P. goalparensis is the principal source of bonsum timber. The wood is light (sp. gr., 0.50; av. wt., 497 kg./cu. m.), is not difficult to season, and takes preservative easily. It is easy to work. Though somewhat interlocked-grained, it can be easily peeled on rotary lathe. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: weight, 75; strength as a beam, 65; stiffness as a beam, 70; suitability as a post, 65; shock-resisting ability, 65; retention of shape, 75; shear, 90; and hardness, 55 [Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1,** 94; Dabral *et al., Indian For. Rec., N.S., Silvicult.,*

* Kostermans considers this species as conspecific with *P. hainesiana* Brandis (*Reinwardtia*, 1961 62, **6,** 281).

1963, **11,** 51 ; Limaye, *Indian For. Rec., N.S., Util.,* 1942, **2,** 168 ; 1944, **3**(5), 22].

The wood is used for house construction, planking, furniture, cabinet-work, commercial and tea chest plywood, bobbins, and occasionally for pattern-making. It is suitable for plywood, spars, propellers, and air-screws in aircraft construction (Trotter, 1944, 190–91 ; *Indian For.,* 1952, **78,** 276, 278, 363 ; Rehman & Askari, ibid., 1956, **82,** 314 ; Dabral *et al.,* loc. cit. ; Limaye, *Indian For. Rec., N.S., Util.,* 1942, **2,** 168).

P. hainesiana Brandis

Brandis, 532.

EASTERN HIMALAYAS—*Angare, angaria.*

A large tree, up to 45 m. in height and 6 m. in girth, found in the eastern Himalayas and Naga hills at altitudes of 900–1,650 m. Bark dark grey, thick ; leaves oblanceolate to obovate, clustered at the ends of branches ; flowers in panicles, grey tomentose ; fruits ellipsoid, black.

The wood (sp. gr., 0.559 ; av. wt., 561 kg./cu. m.) is moderately durable ; graveyard tests indicated a durability of 5–7 years. A number of insect beetles and larvae have been reported to bore into the bark and wood. The wood can be peeled easily without a boiling treatment, but better results are obtained by soaking it in water at about 65° for a period of 15 minutes for every 2.5 cm. of diameter of the log. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are : weight, 80 ; strength as a beam, 80 ; stiffness as a beam, 80 ; suitability as a post, 80 ; shock-resisting ability, 80 ; retention of shape, 75 ; shear, 95 ; and hardness, 70. The wood is used for planks, ceiling and partition boards, veneers, tea chest plywood and laminated boards [Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.,* 1953, **1,** 94 ; Purushotham *et al., Indian For.,* 1953, **79,** 49 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.,* No. 171(7), 1959, 17 ; Limaye & Mohammed, *Indian For. Rec., N.S., Util.,* 1942, **2,** 179 ; Limaye, ibid., 1944, **3**(5), 22 ; Trotter, 1944, 148, 219].

P. lanceolata Nees

D.E.P., VI(1), 198 ; Fl. Br. Ind., V, 141 ; Hara, 103.

HINDI—*Haulia.*

PUNJAB—*Badror ;* DEHRA DUN—*Tumri ;* JAUNSAR—*Bhadroi, bhadeu ;* GARHWAL—*Kekra ;* KUMAUN—*Kaula ;* NEPAL—*Jhankrikath ;* LEPCHA—*Murshionkung ;* ASSAM—*Dieng-jalong, moso-sigar-baphang, chang-check, thang-han-jan.*

A small or medium-sized handsome tree, up to 12 m. in height and 1.8 m. in girth, found in the Himalayas from Simla eastwards, in Uttar Pradesh, Bihar, Assam and in the hills of South India, ascending up to an altitude of *c.* 1,950 m. Bark grey, exfoliating in irregular thin scales, aromatic ; leaves elliptic- or oblong-lanceolate, aromatic ; flowers in lax panicles, yellowish green ; fruits ovoid or ellipsoid, black.

The tree has a fast rate of growth, the annual girth increment being 4–5 cm. A number of insect beetles and larvae are reported to bore into the felled timber. The wood is handsome, olive-brown, close-grained, hard and heavy (av. wt., 801 kg./cu.m.), and is used for planking and canoes. The leaves are used as cattle fodder. The ash of the berries is reported to be used for sores [Troup, III, 788 ; Gamble, 568 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.,* No. 171(7), 1959, 17 ; Rodger, 42 ; Laurie, *Indian For. Leafl.,* No. 82, 1945, 10 ; Fl. Assam, IV, 71].

P. paniculata Nees ; Hook. f. (Fl. Br. Ind.) in part (ASSAM—*Mekahi ;* TAM.—*Sudalan ;* NILGIRIS—*Kumara*) is a tall, handsome tree, found in Central Himalayas and hills of Assam and South India, ascending to an altitude of 2,100 m. The wood is brown, smooth, close-grained, hard and heavy (wt., 769 kg./cu. m.). It is used as fuel and for other domestic purposes (Hara, 103 ; Gamble, 568 ; Krishnamurthi, 220).

PHOENIX Linn. (*Palmae*)

A genus of dioecious, arborescent or shrubby palms distributed in the tropical and sub-tropical parts of Africa and Asia. Seven species occur in India and a few others have been introduced.

Among the Indian species, *P. sylvestris* is widely tapped for its sap, which is converted into palm *gur* (*tad gur, tar gur*) and sugar. Of the exotics, *P. dactylifera,* the Date Palm, has long been introduced in India but is grown only to a small extent in some parts. Considerable quantities of dates are, however, imported and attempts are being made at successful commercial cultivation of some of the well-known varieties of the fruit in the country to meet the demand. Other exotic species are grown mostly for ornament.

P. acaulis Roxb.

D.E.P., VI(1), 199 ; Fl. Br. Ind., VI, 426.

HINDI—*Khajur, jangli khajur ;* MAR.—*Shevra, shilind, boichind ;* TEL.—*Yita ;* ORIYA—*Kojiri.*

NEPAL—*Takul ;* LEPCHA—*Schap.*

A low, handsome palm, found in the outer Himalayas and sub-Himalayan tracts from Kumaun eastwards, Khasi and Naga hills in Assam, Bihar, Orissa, Central India and parts of Deccan Peninsula, up to an altitude of 1,500 m. Stem bulbiferous, 15–25 cm. in diam.; leaves pinnate, 0.6–1.8 m. long: pinnae linear, stiff, 25–50 cm. long; flowers in branched spadices: fruit an oblong-ellipsoid berry, 1.2 1.7 cm. long, bright red to blue-black; seed oblong, grooved. This palm is common and occurs gregariously in open sal forests and in grasslands, particularly on clayey ground; in the outer Himalayas it ascends into *Pinus roxburghii* forests.

The pith of the stem is eaten; it yields a sago. The fruits and the tender peduncles are also edible. The terminal leaf bud forms a good vegetable. The roots and the pith of the young stem are reported to be used as aperients. The leaves are used for thatching and for making mats, brooms, ropes, etc.; they are also lopped for fodder (Bressers, 133; Witt, 224; Bor, 349; Laurie, *Indian For. Leafl.*, No. 82, 1945, 10; Gupta, 495).

P. dactylifera Linn. DATE PALM

D.E.P., VI(1), 199; C.P., 882; Fl. Br. Ind., VI, 424.

HINDI, BENG., MAR. & GUJ.—**Khajur;* TEL.—**Ita, kharjuramu;* TAM.—*Perichchankay, karchuram;* KAN.—*Kharjura;* MAL.—*Ettappazham, tenitta;* ORIYA—*Khorjjuri.*

A tall tree, up to 36 m. in height, cultivated or occasionally found self-sown in some parts of India. Trunk covered with persistent bases of petioles, the base usually surrounded by a mass of offshoots or suckers; leaves in open crown, pinnate, up to 5 m. long, greyish green: pinnae 20–40 cm. long, linear, keeled, lower pinnae modified into spines; flowers in branched spadices, small; fruit an oblong berry, 2.5–7.5 cm. long, reddish or yellowish brown when ripe; seed cylindric, hard, with a longitudinal furrow.

Date palm has been known to exist from prehistoric times in the warm dry zone, extending from North-West Africa to South-West Asian countries. It is extensively cultivated throughout this region. It is believed to be originally indigenous to countries around the Persian Gulf and even today Iraq remains the most important centre of the date production. Dates have been cultivated in West Pakistan, probably since early Mohammedan invasions, and constitute an important fruit crop there. Cultivation of dates has also been taken up in some other warm countries, and in California and Arizona in U.S.A. it has assumed commercial importance.

* The names *Khajur* and *Ita* and their variants and modifications are indiscriminately used for all species of the genus in North and South India, respectively.

There are no commercial plantations of good dates in India at present. Quite a number of trees are, however, found wild or cultivated mostly in dry districts of Gujarat, Rajasthan, Punjab, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh and Mysore, which yield fruit, generally, of an inferior quality. There is considerable scope for commercial cultivation of dates in arid and irrigated regions of North-West India. Recently a number of varieties of merit from South-West Asian countries and U.S.A. have been introduced for cultural trials at Abohar in Punjab and Khedio in Gujarat. Successful selected varieties are proposed to be distributed to other places suitable for date cultivation (Bajwa & Bakhshi, *Farm Bull.*, No. 63, 1961, Bakhshi, *Punjab hort. J.*, 1961, **1**, 34; Bakhshi & Dhillon, ibid., 1962, **2,** 142).

CULTIVATION

Climate and Soil—Date palm is very exacting in its climatic requirements. It requires a long summer with high day as well as night temperatures, mild winter without frosts, and low relative humidity and very little rain, not much exceeding 12.5 cm. during the period of flowering and fruiting. If once established, it can withstand summer temperatures as high as 50°. The mean temperature between the period of flowering and ripening of fruit should be between 25 and 30°, depending upon the variety.

Date palm can thrive on sandy, loamy or clayey soils, but well-drained sandy loam of good depth and water holding capacity is considered the best. Though it requires plenty of water in the soil, comparatively, it needs less water than most other fruit crops and is an important tree in deserts, where it occurs in the oases. Date palm can do well in soils containing more alkali or salts than many other plants will tolerate; best growth and fruit quality, however, cannot be obtained under conditions of high soil salinity (Nixon, *Circ. U.S. Dep. Agric.*, No. 728, 1951; Ochse *et al.*, I, 702; Hill, 418; Bajwa & Bakhshi loc. cit.).

Propagation—Date palm can be propagated by seeds or by offshoots. When grown from seeds, only about half of the trees turn out to be females and they bear fruit of variable quality. Moreover, it takes 4–10 years to determine the sexes of the trees and the quality of the fruit they bear. Sometimes

I.C.A.R., New Delhi

FIG. 11—PHOENIX DACTYLIFERA—PLANTATION

when a seedling turns out to have outstanding qualities, it may be propagated by its offshoots; some new varieties or clones have originated in this way.

For commercial purposes, however, date palm is always propagated by offshoots from desired selected varieties; such trees bear fruit of the same quality as the mother tree. The offshoots arise from axillary buds near the base of the trunk, chiefly during the early life of the palm. Normally, 4–5 years after planting, at least two offshoots can be removed from each tree annually for 10–15 years. Offshoots are detached carefully by cutting as close to the trunk as possible; rooted offshoots are generally preferred in order to reduce mortality. Offshoots are pruned immediately or 4–5 days prior to their removal; only the young leaves and the bases of the old ones are retained. They are removed and planted either in February–April or in August–September. Some growers recommend their seasoning for a few days before planting.

Planting distance depends upon the variety of date, texture and fertility of the soil and the means of irrigation. As in most of the Arab countries, a spacing of 5–8 m. × 5–8 m. has been recommended in India; in U.S.A., a spacing of 9 m. × 9 m. has been considered most satisfactory. The offshoots are buried firmly in the soil up to their maximum diameter, taking care that the crown remains 10–15 cm. above the soil so that the irrigation water does not touch or enter into it. They need protection against heat, cold and winds during the first 2–3 years and are either wrapped with some leaf material or sheltered by suitable coverings. Recently, entire transplanting of mature palms has proved successful in Baghdad (Nixon, loc. cit.; Bajwa & Bakhshi, loc. cit.; Bakhshi & Dhillon, loc. cit.; Nocton, *World Crops*, 1965, **17**, 72).

Manuring and Irrigation—The importance of proper manuring in date cultivation has been well recognized. An annual dose of 50–60 kg. of well rotten farmyard manure or 1–2 kg. of ammonium sulphate per bearing tree has been recommended. In case of a combination of farmyard manure and nitrogenous fertilizer, the doses should be halved. The application should be made twice a year in equal halves, one in January–February and the other in August–September. Cow dung manure at the rate of c. 45 kg. per tree may be applied before the commencement of spring growth; the dose is repeated every 2–3 years. Green manuring with leguminous cover crops, while the palms are young, has given good results in U.S.A.; old leaf and fruit-stalk prunings of the palms are also returned to the soil.

Date palm requires plenty of soil moisture. The frequency of irrigation depends upon soil texture, weather, depth of sub-soil water, etc.; generally, an interval of 10–14 days in summer and 30–40 days in winter is recommended. As the roots of the date palm usually penetrate to a depth of 2–3 m., the soil should be kept moist up to this depth. The date palm is highly tolerant to excessive irrigation and even to floods; permanent waterlogging is very injurious (Nixon, loc. cit.; Bajwa & Bakhshi, loc. cit.; Milne, 11).

Interplanting—Date palm plantations can be interplanted with a variety of crops. During early stages, wheat, barley, vegetables, leguminous fodders and pulses, which do not damage the palm by overshading, can be intercropped. Later, when the palms have grown sufficiently high, low-growing fruit crops such as grapes, pomegranates, figs, peaches, apricots, oranges, etc., can be interplanted (Milne, 9; Bajwa & Bakhshi, loc. cit.; Nixon, loc. cit.).

Pruning—The bearing capacity of date palm is generally proportionate to the number of green leaves

it carries, the optimum being one properly thinned bunch of fruit for 8–9 leaves. It is, therefore, desirable to retain an adequate number of good green leaves and only dead or dying leaves should be removed. Sometimes, however, in order to facilitate cultural operations and reduce damage to the fruit caused by high humidity, it becomes necessary to remove even some of the green leaves. Thorns are removed to facilitate pollination and subsequent handling of bunches. The undesired offshoots are removed while still small, as their presence retards the production of fruit.

Pollination—The date palm generally flowers in March–April and the fruits ripen in August–October. Left to nature, an equal number of male and female trees have to be grown together for adequate pollination. In commercial date production, however, pollination is facilitated by removing two or three strands (branches of spadix) of male flowers from the freshly opened inflorescence of selected male trees and transferring them to the female trees. The male strands are inserted between the strands of female flowers as soon as they open or within two or three days after that; two or three male trees are thus enough to pollinate about 100 female trees. Male trees with thick and bushy inflorescences and abundance of pollen should be selected; early-flowering males should be used for pollinating early-flowering females. In U.S.A., fresh or properly stored viable pollen is sometimes applied by means of cotton plugs. When pollination is satisfactory and fertilization has taken place, only one of the three carpels in the female flower enlarges and the remaining two fall off at about the pea size.

Fruit thinning—Thinning of fruit is necessary to increase the size and improve the quality of the dates, to prevent delayed ripening, to reduce the weight and compactness of the bunches, and to ensure adequate flowering in the following year. Thinning may be done either by reducing the number of fruits per bunch (bunch thinning) or by removing some of the bunches (bunch removal). Bunch thinning is carried out by removing 50–75 per cent of flowers or young fruits in a bunch under normal conditions. This may be done by cutting back the strands or by removing some strands from the centre of the bunch; in practice it is generally desirable to use both the methods. Sometimes bunch thinning is done by removing a certain proportion of flowers or young fruits from individual strands; this method reduces crowding of fruits, but is not used much because of labour and time involved. Bunch removal is done when the number of bunches on a tree is more than it can bear without detriment to its flowering and fruiting the next year (Nixon, loc. cit.; Bajwa & Bakhshi, loc. cit.).

Diseases and Pests—Date palm is reported to be affected by palm-leaf pustule or false smut [*Graphiola phoenicis* (Moug.) Poit.]. The disease occurs as small hard black pustules on both surfaces of the leaflets; old leaves are more severely attacked. Pruning of affected leaves and spraying with Bordeaux mixture or potassium permanganate solution have been recommended. Date palm is also susceptible to pin-head spot [*Diderma effusum* (Schwein.) Morgan], grey blight (*Pestalotia palmarum* Cooke), spongy-white rot [*Polyporus adustus* (Willd.) Fr.], and a few other diseases (*Indian J. agric. Sci.*, 1950, **20**, 107; Information from F.R.I., Dehra Dun).

The larvae of the red weevil or Indian palm weevil (*Rhynchophorus ferrugineus* Oliv.) and the rhinoceros beetle or black-palm beetle (*Oryctes rhinoceros* Linn.) bore tunnels in the stem, generally near the top, which might wither and die or break as a consequence. The insects can be killed with wires or by injecting suitable insecticides into the tunnels. Seriously affected trees should be removed and the insects destroyed. Several other insects cause considerable damage to the stem and leaves. The affected leaves should be removed and the remaining ones sprayed with a suitable insecticide; flame treatment has been very successful in U.S.A. [Hayes, 412; Mathur & Balwant Singh, *Indian For. Bull.*, *N.S.*, No. 171(7), 1959, 19; Nixon, loc. cit.].

The ripening fruits are subject to damage by birds and insects. They may be protected with paper bags or tubes, light porous-cloth, netting, thorns, etc., in such a way as to least interfere with bunch ventilation. In West Pakistan, stored dates have been reported to be attacked by a number of insects including a tineid moth and a beetle (*Lesioderma testacea* Duft.). Protection from insects and sterilization of the fruit before packing have been recommended.

Harvesting and Yield—According to the stages of growth and ripening, the fruit has been classified in West Pakistan into four stages or categories, viz. *gandora, doka, dang* and *pind*, corresponding to *kimri, khalal, rutab* and *tamar* respectively of the Arabs. In the youngest or *gandora* stage, the fruit grows rapidly in size and is distinguished by green colour. The fully grown fruit having red, yellowish

FIG. 12—PHOENIX DACTYLIFERA—FRUITS

(upper) Hard dried dates (Chhuhara); (lower) Dried dates (Khajur)

red or yellow colour is said to be in the *doka* stage. The *dang* stage is marked by the softening of the tip. Matured fruits which are dry enough to keep well, are said to be in the *pind* stage. All the dates on a bunch, however, do not ripen at the same time.

The stage at which the dates are harvested depends upon the variety (different varieties are eaten in different stages of maturity) and local weather conditions. The Arabs harvest some varieties in the *khalal* stage for immediate consumption, while in other varieties the entire bunch is removed after the dates are fully ripe. In U.S.A., the fruits of some varieties are picked as they ripen involving several pickings over a period of 3–4 weeks for early varieties and 2–3 months for the late ones. In West Pakistan, dates are generally harvested before they are fully ripe, to minimize damage due to wet weather. In India, harvesting the whole bunch when some fruits have reached the *dang* stage has been recommended.

Most varieties of date palm, if cared well, start bearing in the fourth year and reach full bearing 10–15 years after planting; the average bearing life is *c.* 50 years. The yield of fruits per palm varies considerably according to the variety and climatic conditions. Average annual yield per tree has been estimated at about 45 kg. Much higher yields, up to 240 kg. have, however, been obtained (Bajwa & Bakhshi, loc. cit.; Nixon, loc. cit.; Hayes, 413).

Varieties There are numerous varieties of dates grown in various date-growing countries of the world, of which only a few are of any real commercial importance. On the basis of their texture at maturity, the date varieties are generally classified into three groups: soft, semi-dry and dry. Among the important varieties grown in West Pakistan and U.S.A., are *Hillawi, Khadrawi* and *Sayer* of the soft type and *Zahidi* and *Dayeri* of the semi-dry type, all from Iraq. *Deglet Noor*, a semi-dry variety from Algeria, has assumed the greatest commercial importance in U.S.A. *Thoory* is a dry date from Algeria and is reported to be the source of *Chhuhara* of Indian bazaars. All these varieties and some others have been introduced at Abohar (Bajwa & Bakhshi, loc. cit.; Nixon, loc. cit.; Bakhshi, loc. cit.).

Curing and Marketing of Dates

Fresh dates are eaten in different stages of maturity, depending upon the variety; local demand and marketing are accordingly determined by consumer preferences. Most varieties are very astringent in the *doka* stage, but some are quite palatable and are eaten in this stage, especially by the Arabs. The dates are very delicious in the *dang* stage, when they are still plump, and are consumed as such in large quantities. The fruit at this stage, however, has high moisture content; it ferments quickly and will not keep, even for a few days, without cold storage. For dessert purposes, dates past this plump stage are preferred.

For commercial purposes, dates are cured or dried after harvesting, so that they can keep for a long time. The optimum stage of maturity for curing depends upon the variety, climatic conditions, local demand and various other factors. Dipping the dates in 1 per cent boiling lye solution and then rinsing in water prior to drying has been recommended: this reduces the drying period, cleans the fruit, improves the appearance and kills insect eggs. Such fruits, however, are not as sweet as the undipped ones.

In West Pakistan, dates are generally picked in the *dang* stage and are cured by sun-drying on date leaf

mats; drying generally takes 3-7 days, resulting in the loss of at least 33 per cent of the weight. Suitable home driers or boxes, made of tin sheet and wood with holes or slits for air circulation, for curing dates by heating are also used: fruit dried in this way is cleaner and better in quality. As picking in the *dang* stage is laborious and expensive, harvesting in the *doka* stage has also been recommended. Some inferior quality dates are picked while still hard and are boiled in water to which a little oil, ghee or milk and sometimes salt is added. They are then dried hard and are called *bhugrian*. A few varieties of dates are split, deseeded and dried (Bajwa & Bakhshi, loc. cit.; Girdhari Lal *et al.*, 242).

In U.S.A., dates are generally dried in dehydrators after fumigation, cleaning, grading and artificial ripening: hydration is sometimes resorted to, to improve the consistency of some of the drier varieties. *Deglet Noor* dates can be stored for one month at 27°, three months at 16°, eight months at 4°, and one year at 0° (Nixon, loc. cit.; *Chem. Abstr.*, 1957, **51,** 9031).

In most date-growing countries of the Old World, the fruit is generally sent in bulk to the markets and usually packed there in palm-leaf bags for export. In U.S.A., cardboard and light wooden containers are used for packing: such packing is used only for choice varieties in Arab countries. Some commercial packs are pasteurized to destroy pathogenic and spoiling micro-organisms and insects; vacuum pasteurization with high moisture content, however, causes dates to become puffy. *Deglet Noor* dates and some other varieties may be kept in tight cans or glass jars, if the moisture content of the fruit has been lowered sufficiently to prevent souring [Bajwa & Bakhshi, loc. cit.; Nixon, loc. cit.; von Loesecke, 1942, 75; *Indian hort. Abstr.*, 1951, **1**(9), 12].

Imports—Considerable quantities of dates are consumed in India, which are imported mainly from Iraq, Muscat, Iran and Saudi Arabia. They are sold in two forms in the market, viz. soft fleshy dates, imported in palm-leaf bags and commonly sold during winter, especially in North India and the hard dry dates or *chhuhara*, available from grocers throughout the country and eaten as restorative or added to sweet dishes. Table 1 gives the import of dates for the years 1962–63 to 1965–66. Small quantities of dates are also re-exported.

Utilization and Chemical Composition

Fruit—Dates are rich in sugars and are eaten fresh or dried. They form an important item of food in the Arabian countries. Dates are widely used in bakery and confectionery. They are made into jams and preserves or added in cakes and in dishes with milk, butter, meat, etc.; a type of honey is also prepared from them. Dates are considered demulcent, expectorant and laxative and are used in respiratory diseases and fever; they are also reported to be used in Yemen in cases of memory disturbance. Dates can be canned as a paste after pitting, grinding and mixing with invert sugar syrup. Date-syrup (invert sugars, *c.* 70%), obtained by extracting the fruit with hot water and concentrating it in vacuum, has a mild sweet taste and may be used in the manufacture of gingerbread. Brandy of good quality is prepared from dates; flavoured with anise (*Pimpinella anisum* Linn.) seeds, it is a popular arrack in Arabian countries. In Nigeria, dates mixed with chillies are added to beer to make it less intoxicating. Dates (total dig. nutrients, 59.8%) are also fed to cattle, sheep and goats (Jacobs, II, 1551; Hoppe, 663; Kirt. & Basu, IV, 2562; Hes & Reani, *Quart. J. Crude Drug Res.*, 1963, **3,** 395; Cruess, 565; *Econ. Bot.*, 1958, **12,** 41; Persinos *et al.*, ibid., 1964, **18,** 329; Bawa, *Indian Fmg*, 1950, **11,** 328; *Nutr. Abstr. Rev.*, 1960, **30,** 1503).

Analysis of the edible matter of freshly dried dates (edible matter, 86%; seed, 14%) obtained from Coonoor market, gave the following values: mois-

TABLE 1—IMPORT OF DATES
(Qty in tonnes and Val. in Rs.)

	1962-63		1963-64		1964-65		1965-66	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Soft fleshy	21,942*	10,538,193	39,224*	12,187,019	53,564†	21,895,323	42,419	16,632,462
Hard dry	11,190	11,750,055	15,201	9,880,755	13,362	11,379,111	10,877	10,944,963
Total	33,132	22,288,248	54,425	22,067,774	66,926	33,274,434	53,296	27,577,425

* Soft fleshy dates were specified as "fresh dates" in the trade statistics during 1962-63 and 1963-64.
† In addition 3,681 tonnes of fresh dates valued at Rs. 1,303,170 were also imported.

ture, 15.3 ; protein, 2.5 ; fat, 0.4 ; carbohydrates, 75.8 ; fibre, 3.9 ; mineral matter, 2.1 ; phosphorus, 0.05 ; and calcium, 0.12% ; iron, 7.3 mg. ; carotene (as vitamin A), 44 I.U. ; thiamine, 0.011 ; riboflavin, 0.023 ; nicotinic acid, 0.9 ; and ascorbic acid, 3 mg./100 g. ; calorific val., 317 cal./100 g. The mineral composition of dried dates from a foreign source was as follows: potassium, 754 ; calcium, 67.9 ; magnesium, 58.5 ; iron, 1.61 ; copper, 0.21 ; phosphorus, 63.8 ; sulphur, 51.0 mg./100 g. Presence of zinc, arsenic, and iodine (6.3 μg./100 g.) is also reported [Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**(2 & 3), 151 ; McCance & Widdowson, 75 ; Winton & Winton, II, 486 ; Iodine Content of Foods, 97].

The main components of ripe dates are sugars, constituting up to 85 per cent of total solids. The major sugar which accumulates at the ripe stage depends on the variety. Sucrose is the predominant sugar in the dry varieties ; sucrose and invert sugar are present in comparable degree in the semi-dry types; and invert sugar predominates in the soft dates. The concentration of sucrose and invert sugar in the dates is determined by the presence or relative absence of the enzyme invertase. At some stage of their development, all dates contain a high percentage of sucrose, and bulk of the invert sugar present in the soft varieties results from inversion of sucrose. Besides sucrose and invert sugars, rhamnose, xylose, arabinose, ribose, galactose, and galacturonic acid have been identified in the fruit. The greatest influx of sugar into the date takes place shortly before ripening. Dates, therefore, cannot be artificially ripened into an economic product before a certain minimum accumulation of sugar has taken place (Ashmawi *et al.*, *J. Sci. Fd Agric.*, 1956, **7,** 625 ; Cruess, 562 ; Jacobs, II, 1549 ; *Chem. Abstr.*, 1959, **53,** 7328).

The immature fruit contains appreciable quantities of astringent principles which disappear to a large extent at the ripe stage ; tannin content of the ripe fruits ranges from 0.02 to 1.8 per cent. Polyphenols, mainly polymeric leucocyanidins, are present to the extent of 3 per cent in the green dates (*Deglet Noor* variety). The pigments responsible for the colour characteristics of the fresh dates are a mixture of different carotenoids, anthocyanins, flavones and flavonols. Dates contain small quantities of pectin, wax and sorbitol. Invertase and peroxidase are also present (Jacobs, II, 1548, 1550 ; Warth, 156 ; Winton & Winton, II, 486 ; Ashmawi *et al.*, loc. cit. ; *Chem. Abstr.*, 1960, **54,** 6994 ; 1957, **51,** 16743).

Analysis of the edible portion (80%) of the dried, hard preserved dates or *chhuhara* gave the following values: moisture, 11.9 ; protein, 2.9 ; fat, 0.5 ; carbohydrates, 82.9 ; and ash, 1.8% ; calcium, 35.9 ; phosphorus, 129.3 ; and iron, 3.4 mg. ; calorific val., 347 cal./100 g. A sample of preserved dates (Persian) contained: carbohydrates, 67.3 ; calcium, 0.07 ; and phosphorus, 0.08% ; iron, 10.6 mg. ; vitamin A, 600 I.U. ; thiamine, 0.09 ; riboflavin, 0.03 ; and nicotinic acid, 0.8 mg./100 g. ; vitamin C, nil. Sucrose is the chief sugar in *chhuhara* (Khan & Chughtai, *Pakist. J. sci. Res.*, 1956, **8,** 155 ; Sen Gupta, *Indian J. appl. Chem.*, 1958, **21,** 45 ; Nutritive Value of Indian Foods, 68, 103, 133 ; Girdhari Lal *et al.*, 242).

Seed -Date seeds or stones when ground or softened by soaking in water are used for feeding camels, goats, sheep and horses ; they are reported to have been successfully substituted for barley in poultry feed in Egypt. In South India, a paste made from the seeds by trituration with water is applied in eye diseases. Date seeds can serve as a raw material for the preparation of oxalic acid : a yield of 65 per cent was obtained by digesting the seeds with concentrated nitric acid and then treating the digest with a mixture of nitric and molybdic acids. Roasted ground seeds are used as an adulterant of coffee. Small bits of seeds are reported to be used as adulterant of areca-nut bits (Kirt. & Basu, IV, 2562 ; Afifi *et al.*, *Trop. Agriculture, Trin.*, 1966, **43,** 170 ; Dhar, *J. sci. industr. Res.*, 1952, **11A,** 370 ; Allen, VII, 398).

The dried date seeds contain: moisture, 7.9 ; protein, 5.2 ; fat, 6.8 ; carbohydrates, 65.5 ; fibre, 13.6 ; and ash, 0.89%. Presence of sterols of the ergosterol group, and esterone has been reported. The fatty oil from the date seeds resembles palm oil. It is a pale yellowish green liquid with a pleasant odour and has the following characteristics: sp. gr.$^{15°}$, 0.9201–0.9207; $n_D^{40°}$, 1.4574–1.4580 ; acid val., 0.38–0.95 ; sap. val., 206–213 ; iod. val., 50–55 ; R.M. val., 0.9–1.1 ; Polenske val., 2.7–3.0 ; and unsapon. matter, 0.4–2.0%. The fatty acid composition of the oil is as follows: lauric, 8 ; myristic, 4 ; palmitic, 25 ; stearic, 10 ; oleic, 45 ; and linoleic, 10% ; caprylic and capric acids have been identified. The oil has been reported to be used in soap making in Iraq [Thorpe, III, 548 ; Jacobs, II, 1551 ; Bennett *et al.*, *Phytochemistry*, 1966, **5,** 231 ; Eckey, 363 ; *Nutr. Abstr. Rev.*, 1960, **30,** 1503 ; Treakle, *Foreign Agric.*, 1965, **3**(48), 7].

Sap –Date palm is tapped for its sugary sap in some countries of North Africa. The tapping is

usually done by making a circular cut or trough around the base of the exposed terminal bud (by cutting the central leaves) and running the exuding sap through a spout into the collecting vessel; the yield of sap per palm is estimated at c. 10 litres per day. The sap has a sweet taste, pleasing flavour and good nutritive value; it is also cooling and laxative. The sap (sucrose content, 10%) can be used for the preparation of jaggery (*gur*) and sugar. Jaggery made out of the sap contained: moisture, 9.6; carbohydrates, 86.1; protein, 1.5; fat, 0.3; minerals, 2.6; calcium, 0.36; and phosphorus, 0.06%. The sap is also employed for the manufacture of vinegar. Fermentation of sap starts spontaneously; the sap collected in the morning may contain 4–5 per cent alcohol by the evening. The fermented liquor (toddy) is slightly acidic and has a pleasant tang [Dowson, *Trop. Agriculture, Trin.*, 1957, **34,** 295; Kirt. & Basu, IV, 2562; Thorpe, III, 548; Nutritive Value of Indian Foods, 84, 119; Verma, *Indian Fmg, N.S.*, 1960–61, **10**(12), 35].

Other uses—Date palm is one of the most useful trees and all its parts are utilized for various purposes in the countries in which it grows. The leaves are used for thatching, and for making mats, fans, baskets, ropes, etc. The petioles make good, light walking sticks and are also used for making crates, boxes and fishing floats; the lower thicker parts are used as fuel. The leaves, especially the petioles, yield fibre which together with fillers such as groundnut shells may be used in the production of insulating boards. The fibrous covering of the sheathing bases of petiole is used for making pack saddles for oxen and the fibre extracted from it is made into cordage. Green spathes also yield a fibre used for making ropes. The bunches of fruit stalks are used as brooms (*Trop. Abstr.*, 1965, **20,** 318).

The terminal leaf bud is eaten raw or cooked as a vegetable. *Tara* water, a pleasantly aromatic liquid obtained by distillation from the fresh spathes, is highly esteemed in Arab countries and is used for making sherbet.

Date palm yields a light, but fairly durable wood, which is, however, soft internally. The unwanted male palms, and female palms past bearing, are cut and used for house construction, bridges, water conduits, etc. In Morocco, the plant is reported to be used for tanning. Prunings of date leaves and fruit stalks may be used as manure. The leaves contain: nitrogen, 0.4–0.66; phosphorus, 0.025–0.062; potassium, 0.33–0.66; and ash, 10.0–16.4%. The fruit stalks contain: nitrogen, 0.28–0.42; phosphorus, 0.017–0.04; potassium, 3.46–4.94; and ash, 7.7–9.88%. The tree yields a gum which is used in diarrhoea (Blatter, 29–31; Persinos *et al.*, loc. cit.; *Biol. Abstr.*, 1948, **22,** 1929; Kirt. & Basu, IV, 2562).

An estrogenic substance has been isolated from the non-saponifiable fraction of fatty oil from dried pollen. Pollen exhibits a gonadotropic activity on immature rats. The presence of cholesterol and estrone has been recently reported in the pollen (*Chem. Abstr.*, 1958, **52,** 3130; Hassan & Al Wafa, *Nature, Lond.*, 1947, **159,** 409; Bennett *et al.*, loc. cit.).

P. humilis Royle DWARF DATE PALM, HILL DATE PALM

Fl. Br. Ind., VI, 426.

A handsome palm, up to 3 m. in height, sometimes with bulbiferous or short tufted stems, found almost throughout India, chiefly in hilly districts, up to an altitude of c. 2,000 m. Leaves sub-glaucous; pinnae scattered, interruptedly fascicled; fruiting spadix slender, spreading; fruit oblong, c. 1.25 cm. long, pericarp thin.

The economic uses of this palm are similar to those of *P. acaulis*. It yields a sago. The pith from the top of the stem is eaten. The fruits are sweet and edible, but contain little pulp. The leaves are used for making mats, baskets, fancy handbags, etc., and are also suitable for cordage. The wood (wt., 464 kg./cu.m.) is light brown and moderately hard (Wehmer, I, 121; Kanjilal, P. C., 381; Krishnamurti Naidu, 121; Gamble, 731).

Three Indian varieties of this palm have been recognized, which are generally not discriminated in their economic uses; some authors consider them as distinct species. Var. *humilis* (HINDI—*Khajuri*; KUMAUN—*Thankal*) is common in the Himalayas, Assam and Northern and Central India; var. *pedunculata* Becc. (MAR.—*Shewra, shilind*; TEL.—*Kondaita*; TAM.—*Inji, malai-icham*; KAN.—*Sun-ichil*; ORIYA—*Bukhorjuro, kojiri*) is distributed chiefly in the hills of the Deccan Peninsula; and var. *loureirii* (Kunth) Becc. syn. *P. pusilla* Lour., non Gaertn. occurs in Khasi hills and Manipur, and is a good pot plant (Blatter, 17–21; Bailey, 1949, 171).

P. paludosa Roxb.

D.E.P., VI(1), 207; C.P., 868; Fl. Br. Ind., VI, 427.
BENG. & ORIYA—*Hital*; TEL.—*Hintalamu.*

A handsome palm, often with inclined or soboliferous stems, up to 8 m. in length and 9 cm. in diam., found in the coastal swamps of West Bengal, Orissa

and the Andamans; it occurs gregariously, forming impenetrable thickets. Leaves spreading, up to 3 m. long: pinnae 30–60 cm. long, whitish or farinose underneath; spadices *c.* 45 cm. long: male flowers yellow, female greenish: fruit an ovoid berry, *c.* 1.25 cm. long, black purple when ripe.

The leaves are used for thatching and for making rough ropes, fences, etc. They were tried for paper making but pulp yield was low (25%). The leaves (tannin, <7%) have been found to be unsuitable as a tanning material. The stems of smaller plants are used as walking sticks; larger stems serve as rafters. The fruits are eaten; they are reported to possess cooling and antiphlogistic properties. The pith of the stem is also edible (Burkill, II, 1714; Nadkarni, I, 946).

P. pusilla Gaertn. syn. *P. farinifera* Roxb.

D.E.P., VI(1), 206; Fl. Br. Ind., VI, 426.

Tel.—*Chiruta-ita, chitti-ita*; Tam.—*Ithi, sagi* Kan.—*Hullichala, sanna-ichalu*; Mal.—*Eentha, chittintal.*

A shrubby palm found on the Coromandel coast and in other parts of South India. Stem very short, 35–45 cm. long, enveloped in old leaf bases; leaves 1.0–1.5 m. long: pinnae 4-farious, sword shaped, pale green; spadices 20–30 cm. long, much branched: male flowers white, female greenish; berry *c.* 1.25 cm. long, dull purple black; seed cartilaginous, longitudinally grooved.

The stem freed from the leaves and the outer woody fibrous covering, yields a farinaceous substance eaten in times of scarcity. The farinaceous matter is separated by beating pieces of stem in a mortar; it is sifted, boiled into a thick gruel or *kanji* and consumed. The gruel affords less nourishment than common sago and is bitter when boiled. The young terminal leaf bud is also reported to be eaten. The fruits are edible and contain a small quantity of sweet pulp. They are prescribed in respiratory disorders and fever. The seeds are made into a paste by trituration with water and applied in inflammation of the eyes. The fresh sap is cooling and laxative. The palm yields a gum which is reported to be used in diarrhoea and urinary disorders (Blatter, 17; Caius, *J. Bombay nat. Hist. Soc.*, 1934–35, **37**, 937).

The leaves are used for thatching and for making coarse mats; the petioles are split and woven into inferior type of baskets. The leaves are reported to afford a valuable fuel for potteries in Mysore (Cameron, 331).

P. sylvestris Roxb. Wild Date Palm, Date Sugar Palm

D.E.P., VI(1), 208; C.P., 885, 929, 1046; Fl. Br. Ind., VI, 425.

Hindi—*Khajur, khajuri*; Beng.—*Khajur, kejur, kajar*; Mar.—*Shindi, boichand, sendri*; Guj.—*Kharak, khakri*; Tel.—*Pedda-ita*; Tam.—*Icham*; Kan.—*Ichalu*; Oriya *Khajuri, kojari.*

A graceful palm, 10–16 m. in height, with a large crown, found throughout India up to an altitude of 1,500 m. Trunk covered with persistent bases of petioles; leaves 3.0–4.5 m. long, greyish green, with a few short spines at the base: pinnae numerous, linear, 15–45 cm. long, ending in short points; flowers in spadices, small, fragrant: male flowers white, female greenish; fruiting spadix *c.* 90 cm. long; fruit an oblong-ellipsoid berry, 2.5–3.2 cm. long, orange-yellow; seed *c.* 1.7 cm. long, deeply grooved, rounded at the ends.

P. sylvestris is common in many parts of India, either wild or cultivated. About 29 million palms are reported to exist in India. It prefers moist alluvial soils, not too heavy and clayey. Natural regeneration takes place freely by seed and the young plants

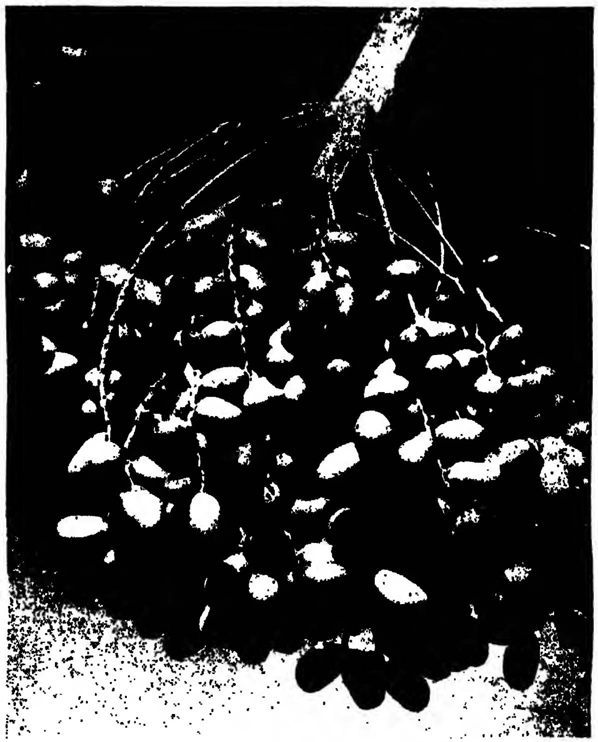


Photo: Ramesh Bedi

FIG. 13—PHOENIX SYLVESTRIS—FRUITING BRANCH

are little subject to browsing. Artificial propagation may be done by transplanting nursery raised seedlings. The seeds are sown in May and the seedlings transplanted in the third year, during rainy season in previously hoed and ploughed soil. When the plants are five years old, the upper green leaves are tied up and the lower yellow ones cut away; this is repeated annually, the ground being well ploughed meanwhile. The palm flowers in the beginning of the hot season and the fruits ripen in September–October. It does not produce offshoots or suckers (Troup, III, 967; Davis, *Sci. Reporter*, 1967, **4**, 70).

Wild date palm is subject to the attack of the following diseases: leaf splitting (*Exosporium palmivorum* Sacc.), pin-head spot (*Grammothele cireracea* Bres.; *Graphiola applanata* Syd. & Butler), false smut [*Graphiola phoenicis* (Moug.) Poit.], sooty mould (*Meliola amphitricha* Fr.; *Meliola palmicola* Wint.) and grey blight (*Pestalotia palmarum* Cooke). A number of insect pests have been recorded affecting the stem and leaves [*Indian J. agric. Sci.*, 1950, **20**, 107; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 20].

Tapping—Wild date palm is tapped in many parts of India for its sap which is converted into palm jaggery (*gur*) and sugar. The trees are generally found growing on the borders of the fields; when especially cultivated for tapping, they are planted in rows with a spacing of 3–4 m. They are ready for tapping at the age of seven years when the stem is *c.* 0.5 m. high, though it is preferable to wait until the eighth or ninth year when the stem attains a height of *c.* 1 m.; tapping can be done for 25–30 or many more years. The tapping season lasts for 4–6 months, commencing from October–November; the yield of sap is maximum during the cold weather and decreases with the onset of hot season.

The crown of the wild date palm is formed by the upper, more or less erect, and the lower, more horizontally inclined leaves. For tapping, the lower leaves along one side of the trunk are cut off and the bark removed to expose the inner soft layer to the extent of *c.* 45 cm. vertically and half of the circumference of the tree horizontally. The exposed surface is brilliant white at first, but soon turns brown. After a few days, the tapping is started in the evening by making a V-shaped cut on the exposed surface and scooping out a triangular area inside the V. The sap, exuding from the scooped surface, is run through a bamboo spout into an earthen vessel, internally coated with lime, and is collected early next morning. A similar,

FIG. 14—PHOENIX SYLVESTRIS—TAPPING FOR NIRA

but somewhat shallow cut is made on the second evening and the sap collected in the same way. The plant is then generally given rest for the next three days, though some amount of sap is collected during third night by merely cleaning the previous cut. This tapping schedule is continued for the season by making fresh cuts. To ensure optimum flow of the sap, fruit bunches are usually cut off. By repeated tapping, the palm gets more and more hewed into, so that at the end of the season the exuding surface is 7.5–10.0 cm. deep. Cuts are made on alternate sides of the trunk in successive seasons giving it a zig-zag appearance. In Bengal, tapping is done at the bases of the lower leaves inclined at *c.* 45° to the horizontal, while in some parts of western India and Andhra Pradesh it is carried out a little higher, at a more delicate portion, at the bases of the leaves making an angle of *c.* 70° to the horizontal. The former method causes less damage to the growing parts and is generally preferred. Recently a new technique has been introduced in which the exposed surface is divided vertically into three equal zones and tapping is done by slicing only one zone daily, thus affording two days rest to each zone. The yield of juice by this

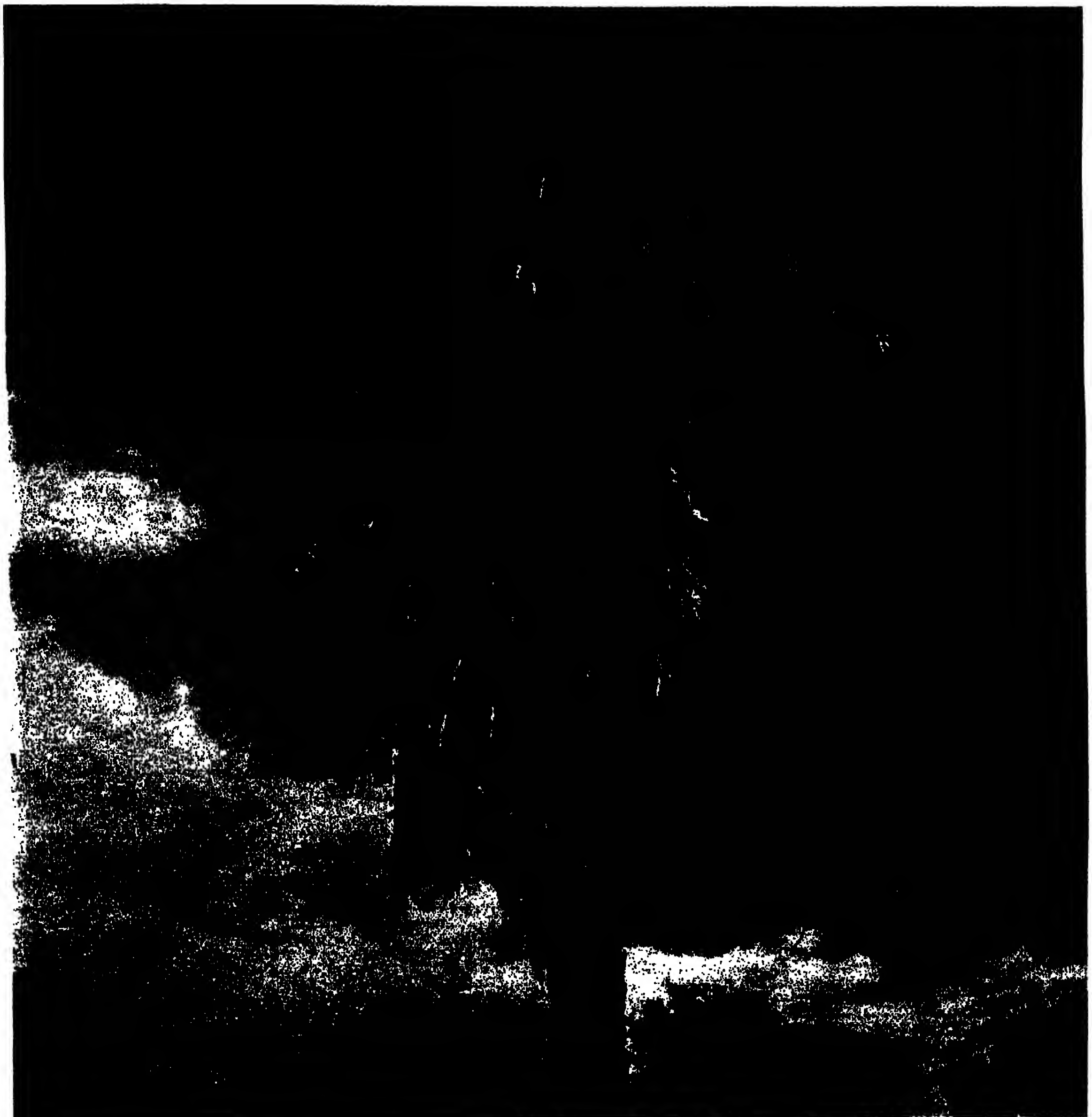


Photo : Naresh Bedi

PHOENIX SYLVESTRIS—TREE IN FRUIT

method is reported to be double. The yield of sap per palm is reported to vary considerably from 70 to 310 kg. in a season, giving 10–13 per cent of its weight as *gur* (Troup, III, 967; Bhate, *Bull. Dep. Ind. & Comm., Industr. Lab., Hyderabad,* No. 7, 1949; *Tad Gud Parichaya,* 1958, 14).

Sap—Fresh unfermented sap (*nira*) is a refreshing sweet drink. It is utilized for the preparation of *gur* and sugar. The sap after it has undergone spontaneous fermentation for 8 to 10 hours is a common beverage (toddy), in certain parts of India. It is also used to a limited extent for making vinegar.

Nira can be pasteurized at 76–80° and bottled without spoiling its natural flavour; addition of sodium benzoate in combination with a small quantity of citric or malic acid makes pasteurization more effective. A process has been patented for the preservation of *nira* by the addition of ammonium hydroxide. Recent experimental trials have shown that paludrine (150 mg./l.) arrests fermentation for more than 72 hours; traces of paludrine can be removed from the *nira* by passing it through a column of activated charcoal. The sap may be concentrated to a moisture content of 5 per cent by the use of a double drum drier (Basrur & Qureshi, *J. Osmania Univ.,* 1939, **7,** 19; Baliga & Ivy, *J. agric. Fd Chem.,* 1961, **9,** 149; Chakravorty, Indian Pat., No. 42938, 1951; Sarma, *Res. & Ind.,* 1963, **8,** 221; Bose & Majumder, *Food Technol., Champaign,* 1950, **4,** 54).

Nira is a good source of vitamins of the B group and contains appreciable amount of ascorbic acid. Analysis of the fresh sap gave the following values: sp. gr., 1.07; *p*H, 6.75; protein, 0.37; total sugars, 11.01; reducing sugars, 0.97; mineral matter, 0.54; and phosphorus, 0.16%; calcium, trace; iron, 0.04; thiamine, 13.30; riboflavin, 0.01; and ascorbic acid, 9.46 mg./100 ml. It contains also nicotinic acid (up to 3.35 mg./100 ml.), *iso*nicotinic acid hydrazide, and organic acids (0.12%, expressed as tartaric acid). The concentration of ascorbic acid varies from 7.1 to 12.5 mg./100 ml.; value as high as 29.9 mg./100 g. has been reported for a sample of *nira*. Ascorbic acid in *nira* is highly stable; loss of the vitamin on storage of *nira* for 15 days at 37° was less than 10 per cent. The stability of ascorbic acid is attributed to the presence of glutathione, *c.* 0.07 g./l. (Baliga & Ivy, loc. cit.; Bhagwat & Sohonie, *Sci. & Cult.,* 1955–56, **21,** 265; Guttikar & Sohonie, *Curr. Sci.,* 1952, **21,** 137; Bose & Majumder, loc. cit.; Hatwalne & Sohonie, *J. sci. industr. Res.,* 1955, **14C,** 59).

Fresh unfermented sap with alkaline *p*H is used for making *gur*. The content of reducing sugar in the sap should not exceed 2 per cent, otherwise the *gur* does not set properly. Liming of the sap is not preferred as it imparts a dark colour to the *gur*; paludrine-preserved *nira* yields *gur* with better colour, flavour, taste and nutritive value. For the preparation of *gur*, the fresh sap is boiled in big pans; to ensure steady boiling, the scum should be quickly removed at intervals. When the sap attains the proper consistency, it is cooled, aired and poured into pots or trays to get lumps or tablets of *gur*. The product may be refined to different grades of sugar; a product nearly as white as cane-sugar can be obtained after two or three boilings. The palm molasses can be used for edible purposes, and as a source of alcohol (Bhate, *Bull. Dep. Ind. & Comm., Industr. Lab., Hyderabad,* No. 9, 1925; Sarma, loc. cit.; Joshi & Shahi, *Khadi Gramodyog,* 1965–66, **12,** 834).

Palm *gur* is reported to be more nutritious than cane *gur*. The vitamin content of palm *gur* is as follows: thiamine, 0.018–0.029; riboflavin, 0.42–0.46; nicotinic acid, 3.92–4.50; and vitamin C, 5.2–30.0 mg./100 g. The *gur* contains the following minerals: calcium, 0.202–0.357; phosphorus, 0.035–0.220; iron, 0.0049–0.0089; sodium, 0.006–0.025; and potassium, 0.100–0.162%; copper, cobalt, nickel, magnesium and molybdenum are present. The major portion (60–80%) of total nitrogen in the *gur* is present in the non-protein fraction. The amino acids present in the non-protein fraction are: lysine, 3.40; phenylalanine, 0.315; leucine, 8.0; threonine, 11.62; *iso*leucine, 2.025; tyrosine, 37.50; and cystine, 33.20 mg./100 g. The concentration of amino acids in palm *gur* is much higher than in cane *gur* (Hatwalne & Sohonie, *Curr. Sci.,* 1952, **21,** 349; *Tad Gud Parichaya,* 1958, 38; Joshi & Sohonie, *J. sci. industr. Res.,* 1957, **16C,** 119; Nath & Uppin, ibid., 1961, **20D,** 40).

Analysis of the toddy gave the following values: sucrose, 0.36; reducing sugar, 0.17; total acids (as tartaric), 0.94; alcohol, 3.61; glycerol, 0.33; ash, 0.196; nitrogen, 0.12; and phosphorus (P_2O_5), 0.55 g./100 ml. Toddy is stated to possess a higher growth promoting potency than *nira*; it nourishes micro-organisms which synthesize and secrete some vitamins during growth. It makes a nutritious drink, especially for those suffering from thiamine deficiency; it also contains more riboflavin than *nira* (Basrur & Qureshi, loc. cit.; Rao & Sreenivasaya, *Curr. Sci.,* 1949, **18,** 250; Biswas & Guha, *Indian med. Gaz.,* 1935, **70,** 382).

For the preparation of vinegar, sap is allowed to ferment spontaneously in carboys filled up to the brim to avoid direct contact with air: inoculation with yeast is not found to accelerate fermentation. Alcoholic fermentation is complete in 12–15 days during which time the temperature is maintained at 24–27°. The fermented sap is filtered and transferred to another container for acetic fermentation at moderate temperature and with free access to air, till the total acidity reaches about 6.5 per cent (as acetic acid) after a period of about 3 months. The yield of vinegar is 70 per cent of the weight of the sap [Verma, *Indian Fmg, N.S.*, 1960–61, **10**(12), 35].

Fruit—The fruits are edible, but are of an inferior quality. They are considered restorative. They may be preserved as such or made into jellies and jams. The flesh constitutes *c.* 60 per cent of the whole fruit. It contains: moisture, 59.2; proteins, 1.2; fat, 0.4; carbohydrates, 33.8; fibre, 3.7; mineral matter, 1.7; calcium, 0.022; and phosphorus, 0.38%. The fruits can be used for the preparation of vinegar. They are converted into a juice by boiling them with an equal volume of water, followed by pressing, and repeating this operation thrice to get maximum extraction. The juice so obtained (sugars, 15–17%) is inverted by boiling with hydrochloric acid (1–3 ml./l.) and inoculated with a culture of fresh yeast to which some nutrient salts are previously added. Fermentation starts within 24 hours (temperature varying from 26.6° to 32.2°) and lasts for seven days. Acetic fermentation is carried out in open vats by inoculating with pure and vigorous *Acetobacter aceti* or 10 per cent unpasteurized "mother vinegar". The mixture is kept in dark for two months. The vinegar [sp. gr., 1.18; and total acid content (as acetic acid), 4.98%] so obtained is a clear liquid of blackish red colour; 100 kg. of fresh fruits yield 120–150 litres of standard vinegar (acetic acid, $\not<$4%) (Cowen, 96; Das & Sarin, *Industr. Engng Chem.*, 1936, **28**, 814; Nutritive Value of Indian Foods, 68, 103).

Other uses—Leaves of *P. sylvestris* are widely used for thatching and for making mats, fans, baskets, bags, brooms, fishing nets, etc.; they also yield a soft fibre which bleaches well. The petioles are beaten and made into ropes, used for drawing water from wells. Female spadix forms a good brush for whitewashing. Leaf bud and the inner portion of the stem are eaten in times of scarcity. The leaves are also lopped for fodder. The tree yields a light brown, durable wood (wt., 625 kg./cu.m.) consisting of a hard and rough outer cylinder and soft inner portion. It is used for temporary construction, bridges and piers and for tent pegs; trunks freed from pith make excellent water conduits. The tree also yields a gum. The bark contains tannin. The seeds made into a paste with the roots of *Achyranthes aspera* are eaten with betel leaves for ague. The roots are reported to be used in toothache [Mayuranathan, 295; Cameron, 330; Yegna Narayan Aiyer, 1950, 92; Krishnamurti Naidu, 93; Khan, 326; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 160; Chopra, 1958, 519].

P. canariensis Chabaud, a native of Canary Islands, is a hardy, fast growing, ornamental palm up to 15 m. in height, cultivated in some Indian gardens. It is a stately tree with a large crown and is suitable for growing in groups and along avenues and borders of parks and lakes. The seeds contain a fat (8.62%) and *d*-mannan (Blatter, 41; Krishnamurthi, 220; Wehmer, I, 121).

P. reclinata Jacq. syn. *P. spinosa* Thonn., a native of tropical Africa, is a soboliferous ornamental palm, up to 12 m. in height, mostly with several stems and feathery leaves, cultivated in Indian gardens. In Africa, the leaves are used for making mats, caps and ropes; they take colour easily and can be worked into many patterns. The green fruit bunches assume a rich scarlet colour on immersion in water for a few hours and the astringent pulp becomes sweet and edible. The terminal leaf bud is eaten as a vegetable. The sap obtained by tapping near the roots becomes intoxicating like toddy on fermentation (Firminger, 308; Blatter, 39; Dalziel, 509–10).

P. robusta Hook. f. (Mar.—*Shelu*) is a palm with trunk up to 6 m. in height and *c.* 37 cm. in diam., found in Bihar and parts of Deccan Peninsula up to an altitude of 1,700 m. The leaves are used for making mats. The fruit is black, sweet and edible (Blatter, 24; Talbot, II, 548).

P. rupicola T. Anders. is a graceful, slender palm with trunk up to 7 m. in height and *c.* 20 cm. in diam., found in eastern Himalayas and Mishmi hills in Assam; it is also cultivated in gardens. The pith of the stem is farinaceous and can be eaten (Gamble, 730; Burkill, II, 1713; Cowan & Cowan, 136).

P. zeylanica Trimen syn. *P. pusilla* Becc. non Gaertn., a native of Ceylon, is a palm up to 7 m. in height, cultivated in Indian gardens. The leaves take colour easily and are used in making mats, baskets, bags, etc. The fruit is sweet and edible. The pith of the stem is eaten in times of scarcity (Firminger, 308; Lewis, 360; Gamble, 730).

PHORMIUM Forst. (*Liliaceae; Agavaceae*)

D.E.P., VI(1), 215; Bailey, 1949, 239.

A small genus of stout, tufted, perennial herbs, native of New Zealand and Norfolk Island. *P. tenax* Forst. (New Zealand Flax, New Zealand Hemp) is widely cultivated in cool tropics and warm temperate regions for fibre and ornamental foliage. It has been introduced in gardens in the hills of South India and is reported to be growing well in Ootacamund; its cultivation for the extraction of fibre has been recommended (Firminger, 314: Krishnamurthi, 254).

P. tenax is a robust, perennial herb with a stout branching rhizome, bearing fan-shaped clusters of large radical leaves; leaves sword-shaped, longitudinally folded, 1–4 m.×4–12 cm., dark green with orange or reddish margin; flowers in panicles, up to 5 m. long, yellowish red; capsules 5–10 cm. long, many seeded. The herb can be easily propagated by seeds or divisions.

The leaves yield a valuable hard fibre which is mostly concentrated in the midrib. First harvest of leaves is taken when the plants are 3-6 years old: thereafter the harvesting cycle varies. Fibre is extracted by scraping the leaves by hand or crushing them in machines. It is washed, dried in the sun and scutched to remove adhering pulp. The yield of dry fibre is 15-20 per cent of the weight of fresh leaves. The commercial fibre (length, 1.2–2.7 m.: ultimate cell, 2–15 mm. long, 5–25 μ diam.) is creamy white with reddish yellow tinge, lustrous, soft and flexible and can be easily dyed. It is chiefly used for towlines, twine and other cordage, mattings, and to some extent for shoe soles and cloth: in New Zealand, it is largely used for making packing bags for wool. The tow is used for stuffing mattresses and as binding material for certain plasters. Analysis of the fibre shows: moisture, 10; fat and wax, 0.70; water solubles, 2.20; lignin, 11.20: cellulose, 45.10: hemicellulose, 30.10; and pectin, 0.7%. The fibre yields up to 60 per cent of a pulp suitable for making writing and wrapping paper and rayon. The pulp can be fermented to produce alcohol and the residue can be used as cattle feed (Weindling, 112; Matthews, 418–24 Harris, 70: *Fibres*, 1953, **14,** 247: Hill, 38: Critchfield, *Econ. Bot.*, 1951, **5,** 172: Thorpe, VI, 165: *Chem. Abstr.*, 1931, **25,** 2562; 1935, **29,** 6050: *Bull. imp. Inst., Lond.*, 1929, **27,** 8: *Hort. Abstr.*, 1967, **37,** 662).

The seeds yield up to 30.7 per cent of a brown coloured semi-drying oil of potential use in the paint and varnish industry. The gum exuding from bases of leaves and the nectar of flowers are reported to be collected and eaten in New Zealand. A decoction of the roots is used as purgative and anthelmintic (Morice, *J. Sci. Fd Agric.*, 1962, **13,** 666: Critchfield, loc. cit.).

PHOSPHATIC MINERALS

C.P., 772.

Phosphorus forms about 0.12 per cent of the earth's crust and is an essential constituent of living matter. It occurs in nature in the form of phosphates. The minerals rich in phosphates include apatite $3[Ca_3(PO_4)_2]$. $Ca(F, Cl)_2$, collophane $Ca_3(PO_4)_2$. $CaCO_3$, monazite (Ce, Nd, Pr, La) PO_4] + $Th_3(PO_4)_4$], triplite $(Fe, Mn)_3$ $(PO_4)_2$. (Fe, Mn) F_2, and vivianite Fe_3 $(PO_4)_2$. $8H_2O$. Apatite is the most common mineral, though good crystalline deposits are comparatively rare. Varieties of native calcium phosphate found in fibrous, compact or earthy masses, often nodular and more or less impure, are termed phosphorite. Phosphorite is a mineral of great economic importance and is extensively used in the manufacture of superphosphatic fertilizers. Many of the impure substances so utilized are not strictly phosphorite but pass under such names as rock phosphate or when nodular, as "coprolite", even though they have little to do with fossilized excreta of animals.

Apatite (sp. gr., 3.2; H., 5) is available in two varieties, viz. fluor-apatite $(CaF)Ca_4P_3O_{12}$ and chlor-apatite $(CaCl)Ca_4P_3O_{12}$. Apatite crystals may be colourless and transparent or white and opaque, but are often coloured, usually some shade of green or brown and occasionally violet, sky-blue, or yellow. Apatite crystallizes in the hexagonal system in short to long prisms terminated by dipyramids and basal pinacoids. Massive, granular, globular, and other types are also common. Apatite minerals may be fluorescent or phosphorescent.

Apatite as small grains is found in nearly all igneous and metamorphic rocks, in high temperature hydrothermal veins, and in some iron ores. Pegmatitic veins may contain large crystals. Apatite minerals constitute the bulk of marine sedimentary phosphate rock and fossil bones. In marine phosphate rock the cryptocrystalline grains of apatite are called collophane (sp. gr., 2.6–2.9; H., 2–5). Marine phosphate rock contains a small quantity of uranium possibly as a result of uranium replacing calcium in the rock. Apatite is soluble in water containing carbonic or organic acids and may be the ultimate source of various mineral phosphates (Krishnan, *J. sci. industr. Res.*, 1944–45, **3,** 466; Wlth India—Raw Materials, I,

199; Wlth India—Industrial Products, pt IV, 14; pt VI, 302; Encyclopaedia Britannica, XV, 528; McGraw-Hill Encyclopedia of Science and Technology, I, 489; Fermor, *Rec. geol. Surv. India,* 1921, **53,** 294).

Monazite (sp. gr., 5.25; H., 5.5) is a mineral consisting essentially of phosphates of cerium and few other rare earth metals; thorium is usually present. It is used as a source of the rare earths and thorium. Phosphate is recovered from the monazite (P_2O_5, 26–28%) in the Rare Earths Factory at Alwaye, in the form of trisodium phosphate, used in textile and chemical industries (Wlth India—Raw Materials, VI, 413).

The phosphates of commerce are mainly derived from the phosphatic rocks occurring among the sedimentary strata, ranging in age from the Cambrian to the Recent. Many of the oceanic islets composed of coral limestone have been phosphatized by the soluble phosphates washed out of guano by rain. The leached guanos and phosphatized rocks have been obtained in large quantities from many islands of the Pacific Ocean (Encyclopaedia Britannica, XV, 528; Coggin Brown & Dey, 475).

The main phosphate producing countries in the world are U.S.A., Morocco, Tunisia, U.S.S.R., Algeria and U.A.R. The world's production of rock phosphate during the years, 1964, 1965 and 1966 was: 69,000; 76,000; 88,000 thousand tonnes respectively (*Indian Miner. Yearb.,* 1964, 231; *Statist. Summ. Miner. Ind.,* 1961–66, 290–91).

Distribution

Andhra Pradesh—Apatite is a universal constituent of the rocks of Kodurite series. It occurs in abundance at the manganese mines of Garbham (18°22′:83°31′), Ramabhadrapuram (18°30′:83°20′) and Devada (18°15′:83°38′) in Srikakulam. A lens-like deposit of apatite rock has been located on a hill near Sitarampuram in Vishakhapatnam district (Chatterjee, 410; Krishnan, *J. sci. industr. Res.,* 1944–45, **3,** 466).

Bihar—Workable deposits of apatite (P_2O_5, 20–29%) are found as veins in the schists, along the copper belt over a distance of 65 km. from Dhadkidih (22°06′:86°06′) in Seraikela to Khejurdari (22°24′:86°34′) in Singhbhum, and extend in Mayurbhanj district of Orissa. The belt is divided into three main sections: (*i*) from Nandup on Seraikela border to Chandar Buru, (*ii*) Pathergora, and (*iii*) from Badia to Sungri and Khejurdari. The apatite rock near Chandar Buru represents an average apatite-chlorite-magnetite rock; at Pathergora, it is particularly high in iron, grading to iron ore: the apatite at Badia is similar to Chandar Buru rock, and some of the veins at Sungri contain white coloured apatite free from magnetite and chlorite (*Indian Miner. Yearb.,* 1960, 57; 1964, 224).

The mica-peridotite dikes occurring in the coal fields of Bihar and West Bengal sometimes contain 10-11 per cent apatite in the rock. Large masses of triplite occur in mica mine situated about 3 km. to the south-east of Singar (24°34′:85°33′) in Gaya (Krishnan, *J. sci. industr. Res.,* 1944–45, **3,** 466; Chatterjee, 410).

Gujarat—Apatite occurs in manganiferous rocks at Jothvad (22°23′:73°47′) in Panch Mahals; in several of them it constitutes almost a quarter or a third of the rock. Nodules of triplite are found in the gneissic terrain near Dohad (22°52′:74°16′) (Chatterjee, 410).

Madras—Phosphatic nodules, light yellow to buff in colour, occur over an area of 30 sq. km. in Cretaceous rocks in Tiruchchirappalli district. Phosphatic deposits associated with sandy shales have also been recorded in South Arcot district and Pondicherry near Tultipattu and Akasampattu villages (*Indian Miner. Yearb.,* 1960, 57).

Other States—In Uttar Pradesh, low to medium grade phosphorite deposits (P_2O_5, 5–34%) occur in a band of shale overlying the Mussoorie limestone. The deposits may extend to *c.* 650 km. Prospecting work in Chamsari and Paritibba areas has given promising results. The phosphorite deposits located at Jaisalmer in Rajasthan, though of higher grade (P_2O_5, 15–35%), appear to be less widespread. Large deposits have been reported on eastern and western coasts of India. Vivianite was observed in Sibsagar district of Assam and at Jamalpur in West Bengal. Vivianite and collophane occur in Karewas of Kashmir. Occurrence of triplite has been recorded in abandoned mica quarries near Tihari and Sanod in Ajmer, and at Rewat in Nagaur [Chatterjee, 410, 412; *Chem. Weekly,* 1964–65, **9**(38), 8; 1966 67, **11**(22), 12; Krishnan, *Rec. geol. Surv. India,* 1941, **76**(4), 18].

Reserves

The total estimated reserves of phosphate deposits in India are tentatively placed at 8.9 million tonnes; according to the Geological Survey of India, the reserves are as follows: Tiruchchirappalli (phosphatic nodules), 8.00; Vishakhapatnam (apatite), 0.17; and Singhbhum (apatite), 0.70 million tonnes.

Detailed proving operations in Tiruchchirappalli

district and elsewhere by the Geological Survey of India are expected to substantially enhance the total reserves of this important raw material (*Indian Miner. Yearb.*, 1960, 57; 1962, 162; 1964, 224).

Mining and Beneficiation

The deposits of apatite and rock phosphate, due to their mode of occurrence as lenses, veins and beds, show a great deal of variation in thickness and lateral extension. They are worked by open-cut methods, and because of their erratic nature the work is rather hazardous. Underground mining has been carried out in rocky mountain region of Idaho (U.S.A.). Lump phosphate and coarse materials of high grade are merely crushed and sized for marketing. The unconsolidated material is usually of low grade and requires disintegration, washing and screening, and in many cases treatment and concentration by flotation methods.

Apatite and rock phosphate have been mined in Singhbhum and Vishakhapatnam and also at Tiruchchirappalli. The P_2O_5 content of the material mined over the years 1960-64 varied in the case of Singhbhum deposits from 12 to 23 per cent and from 30 to 42 per cent in the case of Vishakhapatnam deposits. It was 22–25 per cent for Tiruchchirappalli deposits during 1960; no production has been recorded from this area after this period. The phosphates obtained from these mines contain a number of impurities. In the phosphatic nodules of Tiruchchirappalli, the calcium phosphate and calcium carbonate are so intimately mixed that it is a problem to separate them. Trials carried out by the Geological Survey of India showed that the flotation process was not economical for concentration of this ore. Experiments conducted at the National Metallurgical Laboratory, Jamshedpur, indicated that apatite deposits of Bihar can be upgraded by magnetic separation of magnetite contained in the mineral. Further studies are necessary for developing economical processes to beneficiate rock phosphates occurring in various parts of the country (*Indian Miner. Yearb.*, 1960, 57; 1961, 135; 1962, 162; 1963, 198; 1964, 225; Banerjee & Narayanan, *J. sci. industr. Res.*, 1955, **14B**, 242).

Uses, Consumption and Specifications

Superphosphate fertilizer industry is the important consumer of phosphates. The industry generally prefers rock phosphate containing a minimum of 70 per cent BPL (basic phosphate of lime), though rock phosphate of 63–65 per cent BPL is also being used; P_2O_5 content in the mineral should be at least 27 per cent. Iron and aluminium content should be as low as possible because it unnecessarily raises the consumption of sulphuric acid. Silica content should also be restricted to the minimum. However, the presence of $CaCO_3$ (up to 10%) is regarded useful as it makes the phosphate rock more porous and spongy.

Apatite and rock phosphates are also used for the manufacture of phosphoric acid and elemental phosphorus. The Indian Iron & Steel Co., Burnpur, utilizes the entire production of apatite from its mines in Singhbhum district for the production of high phosphorus pig iron, required for spun-pipe and for other casting purposes. Other uses of phosphate salts are in ceramics, pharmaceuticals, textiles, soap making, purification of sugarcane juice, dental cements, fire-proofing and decolourizing and lining of leather in tanning industry.

The fertilizer manufacturing units in the country use imported rock phosphate, and their consumption during 1962, 1963 and 1964 was: 258,470; 392,925; and 450,340 tonnes respectively (*Indian Miner. Yearb.*, 1962, 164; 1964, 228).

Production and Trade

Singhbhum district of Bihar is the principal rock phosphate producing area in the country. Smaller quantities are produced in Andhra Pradesh. Some rock phosphate was mined in Madras State during 1959 and 1960, but after that no production has been reported. The Statewise production of rock phosphates, during 1963–67, is given in Table 1. The output has markedly decreased during recent years mainly due to dwindling production in Bihar.

The indigenous production meets only a fraction of the national requirement of rock phosphates. With the expansion of superphosphate industry, the imports of rock phosphate have shown an upward

TABLE 1—STATEWISE PRODUCTION OF ROCK PHOSPHATE (INCLUDING APATITE)*

(Qty in tonnes)

	1963	1964	1965	1966	1967
Andhra Pradesh	1,277	647	972	2,953	6,520
Bihar	11,850	3,402	6,104	13,322	5,111
Total	13,127	4,049	7,076	16,275	11,631

* *Indian Miner. Yearb.*, 1964, 226; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11&12), 1:20; 1967, **7**(11&12), 1:18.

TABLE 2—IMPORTS OF ROCK PHOSPHATE

Year	Qty (thousand tonnes)	Val. (million Rs.)
1960 61	253.84	21.75
1961 62	253.96	22.96
1962 63	305.89	25.98
1963 64	336.77	27.59
1964 65	426.31	37.44
1965 66	565.69	55.61
1966 67	753.73	113.86

trend (Table 2). The bulk of imports is obtained from Jordan, Morocco, Tunisia and U.A.R.; small quantities are supplied by Netherlands, Norway, U.S.A. U.K. and Spain.

Phosphorite — *see* **Phosphatic Minerals**

PHRAGMITES Trin. (*Gramineae*)

A genus of tall perennial grasses widely distributed in the temperate and tropical regions. Two species occur in India.

***P. communis** Trin. COMMON REED

D.E.P., VI(1), 215; C.P., 777; Fl. Br. Ind., VII, 303.

PUNJAB—*Dila, dambu.*

A coarse reed, with thick creeping rhizome, found in marshes and on the banks of lakes and streams in the Himalayas from Kashmir to Kumaun, up to an altitude of 4,000 m. Stems erect, up to 3 m. high, stout, hollow; leaves linear-lanceolate, 45–60 cm. × 1.3–4.0 cm.; panicles purple-brown, slightly flattened, 15–45 cm. long; grains oblong.

The reed is useful in the manufacture of pulps for rayon and paper. It contains over 50 per cent cellulose and has a fibre 0.8–3.0 mm. long and 5.0–30.5 μ in diameter. The yield of bleached pulp by soda process, at 151° for 5 hours, was 39 per cent from the stalks and 33 per cent from whole reed. Trials have shown that chemical pulps from *P. communis* can be used alone or blended with chemical wood pulps, for making fine book and newsprint papers. Kraft pulps have also been obtained from the stalks and whole reeds, in yields of 48.4 per cent and 46.7 per cent respectively. It has been recommended that for making viscose or printing paper pulp, only stalks should be used. Viscose pulps suitable for rayon manufacture have been prepared from the stalks using a prehydrolysis-sulphate process which facilitates the reduction of ash content to a minimum; the resultant yarns compared favourably in mechanical and chemical properties to commercial wood-pulp rayon. *P. communis* is also useful in the production of homogeneous boards of good strength. It can be processed into a fine fibrous material suitable as a filling material in upholstery. The flowering stalks yield a fibre suitable for rope making (*Bull. imp. Inst., Lond.*, 1935, **33**, 421; *Chem. Abstr.*, 1947, **41**, 858; 1959, **53**, 14515, 20791; 1949, **43**, 398; 1957, **51**, 13392; 1948, **42**, 9198).

P. communis is used for thatching and for making partitions, fences, coarse mats, baskets, sandals, etc. Thin stems are made into pens and the panicles are used for making brooms and for decorative purposes. This reed spreads rapidly by creeping rhizomes; it has long roots and is very useful as a soil binder. At some places, it has been reported to become a troublesome weed; grazing of the young growth by cattle for about 2 years has been suggested as a control measure (Brown, 1941, I, 165; Burkill, II, 1716; Hubbard, 323; *Biol. Abstr.*, 1949, **23**, 1259).

The young shoots are eaten as vegetable in parts of Russia, China and Japan. The stalks exude a manna-like sweet gum which is eaten. The rhizomes and roots are also edible. The rhizomes are rich in carbohydrates. In Kirghizia (U.S.S.R.), they are reported to be dug up, washed, dried and ground to be used as supplement to flour. They contain: moisture, 5.3; nitrogenous substances, 5.2; fat, 0.9; N-free extr., 50.8; crude fibre, 32.0; sucrose, 5.1; reducing sugars, 1.1; and ash (rich in silica), 5.8%. Asparagine (0.1%) is also present. *P. communis* is rich in pentosans and may be used for the production of furfural; nodes and sheaths yield 6.6 per cent and the underground parts over 13 per cent of furfural. The pentosan content increases throughout the growing period and is maximum in the mature reed. The reed can be used also for the preparation of absolute alcohol, feed yeast and lactic acid (Vykhodtsev & Nikitina, *Trudy biol. Inst., Frunze*, 1947, **1**, 1; Mansfeld, 489; Hedrick, 430; Uphof, 276; Wehmer, I, 83; *Chem. Abstr.*, 1959, **53**, 13291; 1958, **52**, 4177; 1962, **56**, 1775; 1962, **57**, 2466; 1949, **43**, 9501).

The reed when young is eaten by cattle and is largely collected for fodder purposes. Analysis of the young grass from Jammu gave the following values (dry basis): protein, 11.4; ether extr., 2.3; carbo-

* Some authors consider *P. communis* Trin. and *P. karka* Trin ex Steud. as synonymous. In that case, the latter name has precedence over the former.

hydrates, 43.1; crude fibre, 31.05; mineral matter (with high silica content), 10.8; calcium (CaO), 0.94; and phosphorus (P_2O_5), 0.39% (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 415; Wehmer, I, 83).

P. communis is used in medicine, especially in East Asia; it is reported to be employed in rheumatic complaints. Rhizomes and roots possess anti-emetic, diuretic and diaphoretic properties and are used in diabetes (Hocking, 169; Hoppe, 664).

The reed is reported to contain a wax and a saponin. Flowers dye mordanted wool to a green shade. Leaves have a high ascorbic acid content (200 mg./100 g.) (Warth, 231; Hocking, 169; Perkin & Everest, 634; *Chem. Abstr.*, 1936, **30**, 1840).

P. karka Trin. ex Steud. syn. *P. roxburghii* (Kunth) Steud.; *P. maxima* Blatter & McCann in part.

D.E.P., VI(1), 216; C.P., 777; Fl. Br. Ind., VII, 304.

HINDI—*Narkul*; BENG.—*Nal*; MAR.—*Nala*; GUJ.—*Nali, nairi*; TEL.—*Nagasvaramu, maitantos*; TAM.—*Perunanal*; KAN.—*Hulugilu*; MAL.—*Nalam, nannana*; ORIYA—*Nolo*.

PUNJAB—*Nara, nal, bagnarri*; GARHWAL—*Bichhra*; KUMAUN—*Karka, khaila, khailuwa*.

A tall reed, with thick creeping rhizome, found in marshy places and along banks of lakes and streams throughout India, ascending up to 1,300 m. in the Himalayas. Stems erect, up to 6 m. high, stout, hollow, close-jointed; leaves linear-lanceolate, up to 62 cm. long and 4 cm. broad; panicles up to 60 cm. long, brownish; grains oblong. The reed is common in many parts of India. An average annual output of c. 174,000 tonnes (dry wt.) is estimated from Nowgong and Sibsagar forest divisions of Assam (Information from Director of Industries, Assam).

The reed on analysis gave the following values (oven dry basis): pentosans, 22.5; lignin, 25.7; cellulose, 55.2; and ash, 3.1%. Laboratory and pilot plant trials carried out at the Forest Research Institute, Dehra Dun, have shown that digestion of the reed by the soda or the sulphate process using 22 per cent of chemicals (based on oven dry raw material) at 153–62° for 6 hours, gives pulps suitable for the manufacture of writing and printing papers. The yield of bleached pulps is *c.* 40 per cent. The pulps are, however, short-fibred (length, 0.5–3.2 mm., diam., 6.6–19.8 μ) and have to be mixed with long-fibred pulps such as those from sabai grass (*Eulaliopsis binata*) or bamboos. The reed stalks have been suggested as a potential source of rayon pulp. They can also be processed to yield chip boards of satisfactory quality. The reed is stated to be suitable as a raw material for the production of furfural (yield, *c.* 7% on dry basis) (Bhat & Virmani, *Indian For.*, 1952, **78**, 127; Latif, *Pakist. J. Sci.*, 1964, **16**, 286; Narayanamurti & Jain, *Res. & Ind.*, 1963, **8**, 4; Lodh & Rao, *J. Instn Chem. India*, 1963, **35**, 48).

Like *P. communis*, this reed is also employed for thatching and for making mats, baskets, chairs, fences, fish traps, etc. The culms are also used for *hookah* pipes, flutes, and pens; the panicles are used for brooms. The flowering stalks yield a fibre suitable for cordage (Burkill, II, 1716; Haines, V, 952).

The reed when young is eaten by cattle. Analysis of the young grass from Kashmir gave the following values (dry basis): protein, 6.6; ether extr., 1.1; carbohydrates, 43.6; crude fibre, 41.7; mineral matter, 6.5; calcium (CaO), 0.33; and phosphorus (P_2O_5), 0.18% (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 415).

P. karka is not discriminated from *P. communis* for medicinal uses; the roots are reported to be used also

Bot. Surv. India. Photo: M. A. Rau

FIG. 15—PHRAGMITES KARKA—FLOATING CLUMPS

for fractured bones (Tiwari, *Indian For.*, 1955, **81,** 191).

PHRYNIUM Willd. (*Marantaceae*)

Fl. Br. Ind., VI, 258; Holttum, *Gdns' Bull.*, 1950–51, **13,** 279.

A small genus of herbs with creeping rootstocks distributed in India and South-East Asia. Some of the species assigned to this genus are now placed elsewhere. Probably 3 or 4 species occur in India.

P. capitatum Willd. syn. *P. malaccense* Ridl. (Beng.—*Kudali;* Lushai—*Hnathial*), a perennial herb with tuberous rootstocks, large radical leaves, 30–45 cm. x 15–24 cm., and purple flowers is found in the eastern Himalayas, North Bengal, Assam, Bihar, Orissa and further south from Konkan to Travancore. It occurs along shady drains and in swampy ground.

In Java, the leaves are used for wrapping parcels. In Indo-China and tropical China, the leaves are wrapped around articles of food, prior to boiling, to impart colour and flavour. They are also used to serve food and for thatching [Burkill, II, 1716; Hedrick, 430; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 365].

Phrynium dichotomum — *see* **Clinogyne**

Phyla — *see* **Lippia**

PHYLLAGATHIS Blume (*Melastomataceae*)

A small genus of herbaceous shrubs distributed in South-East Asia. One species occurs in India.

P. rotundifolia Blume is a small shrub, 30–60 cm. high, with roundish plaited leaves and pink or reddish flowers reported to be found in the Andamans. A decoction of leaves and roots is used in Malaya in malaria and for fevers in children; a decoction of leaves is given in stomach-ache. The roots, pounded with betel, are given as a tonic after childbirth (Burkill, II, 1717; Burkill & Haniff, *Gdns' Bull.*, 1929–30, **6,** 203).

PHYLLANTHUS Linn. (*Euphorbiaceae*)

A genus of herbs or undershrubs chiefly distributed in tropical and sub-tropical regions of the world. About 24 species occur wild in India, and some ornamental exotics are planted in gardens.

A number of species mentioned in Fl. Br. Ind. have been transferred to *Cicca, Emblica, Kirganelia, Prosorus* and *Reidia.* Recently, a revision of the genus, particularly of the West Indian species, has been made and some of the above mentioned genera have been placed back in the genus and ranked as sub-genera. The genus, as circumscribed in the present account, includes only species of the sub-genus *Phyllanthus* (Webster, *J. Arnold Arbor.*, 1956, **37,** 1, 91, 217, 340; 1957, **38,** 51, 170, 295; 1958, **39,** 49, 111).

P. fraternus Webster syn. *P. niruri* Hook. f. (Fl. Br. Ind.), non Linn.*

D.E.P., VI(1), 222; Fl. Br. Ind., V, 298; Webster, *J. Arnold Arbor.*, 1957, **38,** 309.

Sans.—*Bhumyamalaki, bahupatri;* Hindi—*Jaramla, jangli amli, bhuinanvalah, bhonyabali;* Beng. -*Bhui amla, sadahazur-mani;* Mar.—*Bhuivali;* Guj.—*Bhonya anmali;* Tel.—*Nela usirika;* Tam.—*Keela nelli;* Kan.—*Nela nelli, kiranelli gida;* Mal.—*Kizha nelli;* Oriya—*Bhui aola, badianla.*

Delhi—*Dhadhan, mokh, nunki;* Bihar—*Mui koa, kantara, piri kantara, mui ara.*

A herb, up to 60 cm. in height, occurring as a winter weed throughout the hotter parts of India, particularly on cultivated land. Stem angular; leaves distichous elliptic-oblong, or linear-oblong; flowers axillary, yellowish, greenish or whitish, male flowers 1–3, females solitary; capsules depressed-globose, smooth, scarcely lobed; seeds 3-gonous, pale brown, longitudinally ribbed.

P. fraternus is native probably to West Pakistan and western India and has been introduced into Africa and the West Indies. Its closest relative is *P. debilis* Klein ex Willd. The two species, though appearing distinct, are considered to be two allopatric sub-species of a single species, which interbreed where they come together. As evidence of this, it is reported that specimens more or less intermediate between *P. fraternus* and *P. debilis* have been observed in Bengal. *P. fraternus* seems to occupy a range chiefly in West Pakistan and north-western India (Punjab and Uttar Pradesh), while *P. debilis* appears to be mainly distributed from Bombay and Madras south to Ceylon, and also in Sikkim and Bhutan (Webster, *J. Arnold Arbor.*, 1957, **38,** 295).

The herb is bitter in taste, and is reported to possess astringent, deobstruent, stomachic, diuretic, febrifugal and antiseptic properties. It is used in stomach troubles such as dyspepsia, colic, diarrhoea and dysentery, and is also employed in dropsy and diseases of urinogenital system. Fresh roots are said

* *P. niruri* Linn. has been consistently misinterpreted by various authors and for a discussion regarding its true identity and delimitation, reference may be made to Webster, *J. Arnold Arbor.*, 1956, **37,** 1; 1957, **38,** 295.

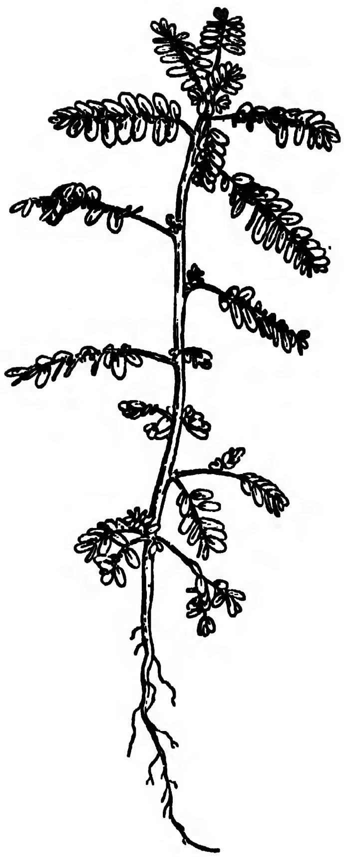


FIG. 16—PHYLLANTHUS FRATERNUS

to be beneficial in jaundice. They are taken with milk as a galactagogue. In Rajasthan, the roots are used for treating camels suffering from digestive troubles. A decoction of the leaves is used as a refrigerant for the scalp. Leaves and roots are made into a poultice with rice water for application on oedematous swellings and ulcers. The latex is also applied to offensive sores and ulcers, and mixed with oil it is used in ophthalmia (Dalziel, 157 ; Nadkarni, I, 948 ; Kirt. & Basu, III, 2226; Chopra, 1958, 595 : Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 23 ; Caius, *J. Bombay nat. Hist. Soc.*, 1938–39, **40,** 304).

The dried leaves contain 0.4 per cent of a toxic bitter principle, phyllanthin ($C_{21}H_{22}O_7$, m.p. 97–98°), traces of a tasteless substance, hypophyllanthin ($C_{15}H_{22}O_6$, m.p. 129–30°) and about 5 per cent of a colourless wax (m.p. 80° ; acid val., 17 ; and sap. val., 92) made up mostly of esters (85%) of long chain fatty acids and alcohols, free fatty acids and hydrocarbons. Phyllanthin is toxic to fish and frog. In frogs it causes depigmentation of the skin, but the colour is regained after about 20 hours. The leaves are rich in potassium (0.83%, fresh basis) which is considered responsible for their powerful diuretic effect (Krishnamurti & Seshadri, *Proc. Indian Acad. Sci.*, 1946, **24A,** 357 ; Wehmer, II, 669 ; Van Steenis-Kruseman, loc. cit.).

Stem contains saponin. A decoction of the stem and leaves dyes cotton black ; sometimes it is substituted for ink. Alcoholic extracts of leaves and roots show antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (Kalaw & Sacay, *Philipp. Agric.*, 1925, **14,** 421 ; Burkill, II, 1719 ; George *et al.*, *J. sci. industr. Res.*, 1947, **6B,** 42).

P. maderaspatensis Linn.

D.E.P., VI(1), 221 ; Fl. Br. Ind., V, 292 : Kirt. & Basu, Pl. 859A.

Hindi & Guj.—*Kanocha, bazarmani, ranavali ;* Tel.—*Nalla usirike ;* Tam.—*Mela nelli.*

An erect or decumbent herb or sometimes an undershrub, 30–90 cm. high, occurring throughout the drier parts of India. Leaves ovate or obovate-cuneate ; flowers in axillary clusters : capsules depressed-globose, 3-lobed or shallowly 6-lobed ; seeds triangular, grey muriculate, prettily marked with dark brown lines.

An infusion of the leaves is used in headache. The seeds possess laxative, carminative and diuretic properties (Kirt. & Basu, III, 2223).

The dried seeds on extraction with light petroleum gave 8.1 per cent of a clear deep yellow oil of a characteristic odour and having the following characteristics: sp. gr.$^{31°}$, 0.7912 : $n^{30°}$, 1.4770 ; acid val., 13.44 ; sap. val., 179.13 ; iod. val. (Hanus), 95.6 ; and unsapon. matter, 1.5%. The fatty acid composition (saturated, 10.2 and unsaturated, 89.8%) revealed the presence of myristic, palmitic, stearic, oleic, linoleic, and linolenic acids. β-Sitosterol and a substance ($C_{22}H_{46}O$, m.p. 72°) have been identified in the unsaponifiable matter (Bhakuni, *J. sci. industr. Res.*, 1959, **18B,** 446).

The defatted seeds yield 15.3 per cent of a dirty-white fibrous mucilage which turns brown on long exposure to air and, on hydrolysis with 2N-sulphuric acid, yields galactose, arabinose and rhamnose, and aldobionic acid. The presence of a reddish brown colouring matter, maderin ($C_{21}H_{20}O_6$, m.p. 290–91° ; yield 0.36%) and an essential oil has also been reported in the seeds (Bhakuni, loc. cit. ; Bhakuni & Joshi, *Proc. nat. Acad. Sci. India*, 1959, **28A,** 34).

P. simplex Retz.

D.E.P., VI(1), 223; Fl. Br. Ind., V, 295; Kirt. & Basu, Pl. 860.

MAR.—*Bhuiavali, motibhuiavali;* GUJ.—*Motibhonyaanmali;* TEL.—*Uchchi usirika.*

ASSAM—*Bon babri;* SANTAL—*Tanda meral;* BIHAR—*Bhuin aonra, xe xel anra, ote meral.*

A herb or an undershrub, sometimes prostrate or ascending, found throughout India. Leaves distichous, linear-oblong to obovate: flowers minute, brownish purple; capsules depressed-globose, slightly 3-lobed, crustaceous, very dark brown.

The plant is said to have antiseptic properties, and the fresh leaves, bruised in buttermilk, are used as a wash for itch. In the Philippines, the juice of the leaves is employed in eye diseases. Fresh leaves, flowers and fruits with cumin seeds and sugar are used in gonorrhoea. A preparation of the root is applied to mammary abscesses (Chopra, 1958, 598; Fox, *Philipp. J. Sci.*, 1952, **81,** 217; Kirt. & Basu, III, 2225).

Fruits contain oxalic acid (Kalyankar *et al.*, *Curr. Sci.*, 1952, **21,** 220).

P. urinaria Linn.

D.E.P., VI(1), 224; Fl. Br. Ind., V, 293; Webster, *J. Arnold Arbor.*, 1957, **38,** 170.

HINDI—*Lal-bhuin anvalah, hazar mani;* BENG.—*Hazar mani;* MAR.—*Lal mundajanvali;* GUJ.—*Kharsadabonyaanmali;* TEL.—*Erra uririka;* TAM.—*Shivappu keela nelli;* KAN.—*Kempu nela nelli;* MAL.—*Chirukizhuka nelli, chuvannakizha nelli;* ORIYA—*Bhuinanla.*

BIHAR—*Muikantara.*

A diffusely branched herb, met with as a weed of cultivated areas throughout India. Leaves distichously imbricate, oblong or linear-oblong; flowers minute, yellowish; capsules globose, scarcely lobed, echinate; seeds transversely furrowed.

The plant is used medicinally in the same way as *P. fraternus*, often as a substitute for it. It is considered to be an excellent diuretic. The leaves are eaten by cattle. The juice of the leaves is given in coconut milk as an appetizer to children (Kirt. & Basu, III, 2224; Burkill, II, 1719).

The herb is reported to contain a neutral bitter principle and an alkaloid. It is used as a fish poison (Chopra *et al.*, *J. Bombay nat. Hist. Soc.*, 1941–42, **42,** 888).

P. lawii Grah. (MAR.—*Kati, khad sherni;* TAM.—*Vattu nelli;* MAL.—*Kuruttu nelli, uri;* BIHAR—*Tirsibirsi*) is a shrub found in Bihar, Orissa, West Bengal and Deccan Peninsula. Its branches are used for making baskets. The twig bark of *P. polyphyllus* Willd., a shrub or a small tree found in the hills of Deccan Peninsula, contains 11–16 per cent tannin; it can be used for tanning. *P. rheedii* Wight is a herb or an undershrub found in Bihar and hills of southern India. It is used by the Mundas in dysentery [Talbot, II, 441; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153; Burkill, II, 1717; Bressers, 21].

Phyllanthus spp. — *see* **Cicca, Emblica, Kirganelia, Prosorus, Reidia**

PHYLLOCHLAMYS Bureau (*Moraceae*)

Fl. Br. Ind., V, 488.

A very small genus of shrubs or small trees distributed from India to Malay Peninsula. One species occurs in India.

P. taxoides Koorders syn. *P. spinosa* Bureau (BENG.—*Sheora;* MAR.—*Kurrera;* TEL.—*Sukali;* ORIYA—*Jhumpuri;* MAYURBHANJ—*Putkuli*), a small evergreen gnarled tree, 1.5–2.4 m. high, armed with sharp spines and bearing irregularly serrate leaves and dioecious flowers, is found in Bihar, Orissa, Deccan, South India and the Andaman Islands. The bark of the plant is boiled to make a poultice for ulcers; it is burnt and the smoke is inhaled to cure cold in the head (Burkill, II, 1720; Burkill & Haniff, *Gdns' Bull.*, 1929–30, **6,** 252).

PHYLLOSTACHYS Sieb. & Zucc. (*Gramineae*)

D.E.P., VI(1), 224; C.P., 105; Fl. Br. Ind., VII, 386.

A genus of shrubby or arborescent, ornamental bamboos distributed from Assam to Indo-China, China and Japan. A number of species are cultivated in the warm temperate regions. Three species occur in India.

P. bambusoides Sieb. & Zucc. is a tall bamboo with erect or ascending culms, sometimes up to 20 m. in height and 12 cm. in diam., reported to occur in Mishmi hills in Assam; it has been successfully cultivated in some parts of Himachal Pradesh and introduced in Dehra Dun and Darjeeling.

This is the well known Giant Timber Bamboo of China and Japan, where it is much used for making printing paper. Sulphate digestion of the bamboo gave 38.3 per cent of bleached pulp (av. fibre length, 1.52 mm.; av. diam., 13μ) suitable for the production of writing and printing papers. Laboratory pulping

test on the U.S.A.-grown samples, using (30–50%) sodium xylene sulphonate as pulping agent, gave 41.6 per cent of unbleached and 39.5 per cent of bleached pulp. The α-cellulose content of the pulp (unbleached, 93.6 and bleached, 92.5%) makes it suitable for the manufacture of rayon without refining. The bamboo is of considerable economic importance in East Asia and is used for constructing houses, bridges, and for making furniture, umbrella handles and walking sticks. The young shoots are eaten as vegetable. In China, the roots are considered tonic and the sprouts parasiticidal. Tabasheer (*banslochan*) obtained from the bamboo is also used in medicine. The oral administration of the extract of culms has been reported to produce rapid hyperglycaemia in rabbits [Information from F.R.I., Dehra Dun; Guha & Pant, *Indian For.*, 1966, **92,** 467; *Agric. Res.*, 1961, **1,** 152; Swallen, *Fieldiana, Bot.*, 1955, **24**(2), 311; *Chem. Abstr.*, 1941, **35,** 6444; 1932, **26,** 5664; Uphof, 276; Young, *Econ. Bot.*, 1954, **8,** 377; Caius, *J. Bombay nat. Hist. Soc.*, 1935–36, **38,** 540].

P. assamica Gamble ex Brandis is a caespitose bamboo with culms, 10–12 m. in length and up to 20 cm. in diam., found in Mishmi hills and Lakhimpur district in Assam; it is also reported to be cultivated near Sibsagar. *P. mannii* Gamble is a closely related species with culms, 5–6 m. in length and 2.5–3.0 cm. in diam., found in Naga and Khasi hills, and commonly cultivated in Shillong. The stems of both these species can be made into good walking sticks (Brandis, 667; Fl. Assam, V, 55; Gamble, 746).

A number of exotic species of the genus have been introduced in Darjeeling. Of these, *P. nigra* Munro, the ornamental Black Bamboo of China and Japan, is reported to be growing well. It is useful for cabinet-making, interior decoration, umbrella handles and paper pulp [Biswas, *Rec. bot. Surv. India*, 1940, **5**(5), 443; McClure, *Agric. Handb. U.S. Dep. Agric.*, No. 114, 1957, 46; Burkill, II, 1720].

PHYMATODES Presl (*Polypodiaceae*)

Beddome, Indian Ferns, 344; Fl. Malaya, II, 188.

A genus of ferns, distributed throughout the tropics of the Old World. Four species have been recorded from India. Some authors include this genus under *Microsorium*.

P. longissima (Blume) J. Smith syn. *Pleopeltis longissima* Moore is a fern with creeping rhizome found floating in *jheels* in Assam and some ravines in Orissa. The young fronds taste like bitter almonds and are eaten as a flavouring (Burkill, II, 1771).

P. nigrescens (Blume) J. Smith syn. *Pleopeltis nigrescens* Carr. is a very handsome fern occurring in hilly places of southern India. In Borneo, it is eaten (Burkill, II, 1771).

P. scolopendria (Burm.) Ching syn. *Pleopeltis phymatodes* Moore is a fragrant fern, very adaptable to rockeries and commonly cultivated in Indian gardens. It yields a coumarin-containing volatile oil, used for scenting coconut oil. It is also reported to contain glycyrrhizin and a saponin. The young fronds are reported to be used in chronic diarrhoea; in Pemba, the fronds are spread on the bed to keep off bed bugs (Burkill, II, 1771; Gildemeister & Hoffmann, IV, 23; Quisumbing, 66; Williams, 259).

PHYSALIS Linn. (*Solanaceae*)

A genus of herbaceous annuals or perennials, mostly natives of tropical North and South America, with a few species widely distributed in the warmer parts of the world. Some species are grown for their edible fruits. One or two species occur wild in India, while three others are cultivated.

P. alkekengi Linn. STRAWBERRY TOMATO, WINTER CHERRY

Bailey, 1947, III, 2608; Waterfall, *Rhodora*, 1958, **60,** 128.

A diffuse perennial, with glabrous or slightly pubescent stems, whitish flowers and reddish fruits, 4–12 cm. long, with blood-red, inflated calyx, often grown as an ornamental plant. It is considered to be a native of the region extending from Japan to South East Europe and is naturalized in many countries. Its occurrence in India, though not definite, is not improbable.

The berries are very juicy and have an acidulous bitter taste. The fruits as well as leaves contain an amorphous bitter principle. The fruits contain also vitamin C, a carotenoid pigment (physalien), and probably an alkaloid. They are reported to be diuretic, febrifuge, hydragogue and vermifuge (Chopra, Nayar & Chopra, 191; U.S.D., 1947, 1551; Steinmetz, I, 26; Wren, 324; Hoppe, 665; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7,** 90).

P. ixocarpa Brot. ex Hornem. TOMATILLO, MEXICAN (MAYAN) HUSK TOMATO

Bailey, 1947, III, 2608; Mansfeld, *Zuchter*, 1954, **24,** 1, Fig. 1.

A glabrous annual, 1.0–1.3 m. tall, native of

Mexico and Guatemala, brought into cultivation some two to three decades ago for its fruits. Leaves lanceolate to ovate, toothed; flowers yellow; fruit calyx 2–3 cm. long, yellowish, purple veined and entirely filled by the large, round, purplish violet, sticky berry and sometimes torn open by it.

This species has recently been introduced into this country. It is said to be highly variable, differing in such characters as day light requirement, length of sepals, texture of flesh and taste of fruit. The strain introduced into cultivation is said to be a low spreading semi-prostrate plant with round, yellow, slightly aromatic fruits 2.5–6.0 cm. in diameter. The flesh of the fruit is light yellow when ripe, firm and mildly acid in flavour [Melhus & Smith, *Iowa Fm Sci.*, 1953, **7**(11), 15].

The tomatillo has been found to perform well both in the summer as well as winter seasons. June and October–December are said to be suitable months for raising the crop. The methods of cultivation are similar to that of tomato. The seeds are very small (wt., 1.3–1.6 g./thousand) and *c.* 150 g. is enough to raise seedlings for a hectare. Seeds are sown in raised beds and 3-week old seedlings are transplanted. In Rajasthan, the plants begin to bear fruits in about 6–10 weeks, and continue for about six weeks; they give 3–4 flushes at intervals of a month. Each plant may bear up to 150–200 fruits, each of which may weigh about 30 g. Daily picking is necessary as the fruits drop immediately after they ripen. The yield per hectare may be 17,000–22,570 kg. [Venkataratnam, *Indian Hort.*, 1956–57, **1**(3), 6; Bhargava *et al.*, ibid., 1962–63, **7**(4), 31; Melhus & Smith, loc. cit.].

The tomatillo is said to be a very hardy plant and is subject to few diseases and pests. Stem and fruit borers are said sometimes to attack the crop during heavy rains, but the winter crop is said to be free. Application of 5 per cent BHC has proved effective in controlling the fruit borer (Venkataratnam, loc. cit.; Bhargava *et al.*, loc. cit.).

The fruits are acid sweet and can be eaten raw like tomatoes or as salad; they can be made into curry, pickles and soup; they can also be made into an attractive jam. Analysis of a sample of fruits from Coonoor gave the following values: moisture, 91.7; protein, 0.7; fat (ether extr.), 0.6; carbohydrates, 5.8; crude fibre, 0.6; and mineral matter, 0.6%; carotene (as vitamin A), 80 I.U.; thiamine, 0.054; riboflavin, 0.023; nicotinic acid, 2.1; and ascorbic acid, 2 mg./100 g. The mineral constituents in the fruit are (mg./100 g.): calcium, 7; magnesium, 23; phosphorus, 40; phytin phosphorus, 7; iron, 1.4; ionisable iron, 1.0; sodium, 0.4; potassium, 243; copper, 0.09; sulphur, 27; and chloride, 14; acid-base balance (ml. of $N/10$ alkali), 38 (Balasubramanian *et al.*, *Indian J. med. Res.*, 1962, **50**, 779; Venkataratnam, loc. cit.; Melhus & Smith, loc. cit.).

P. minima Linn.

D.E.P., VI(1), 224; Fl. Br. Ind., IV, 238.

HINDI—*Tulati pati*; BENG.—*Ban tipariya*; MAR.—*Chirboti, dhan mori*; GUJ.—*Parpoti, popti*; TEL.—*Kupanti, budda budama*; TAM.—*Tholtakkali*; KAN.—*Gudde hannu*; MAL.—*Njodi njotta*.

A herbaceous pubescent annual, 15–30 cm. high, distributed nearly throughout India and ascending up to 2,300 m. Leaves ovate, shallowly toothed or lobed; flowers solitary, clear yellow; berry 8–12 mm. in diam., round, green, many seeded, entirely enclosed in the enlarged membranous calyx, which may be 5- or sometimes 10-ribbed.

The plant is a common weed of irrigated fields and bunds and is very variable. In *P. minima* var. *indica* C. B. Clarke, the leaves and fruiting calyx are more glabrescent and the latter is distinctly 5-angular. *P. angulata* Linn. is sometimes confused with this species, but may be distinguished by its bluish anthers. It is said to occur as weed in cultivated grounds.

P. minima is reported to be a collateral host to the strain of *Xanthomonas vesicatoria* Dowson which infects the chilli (*Capsicum frutescens*). It is also subject to *Xanthomonas physalidis* Srinivasan (Srinivasan *et al.*, *Proc. Indian Acad. Sci.*, 1962, **56B**, 93).

The fruits and leaves are reported to be edible. In parts of Africa, the fruits are used for preserves. The fruits are considered to be tonic, diuretic and purgative. The leaves and roots are used for medicinal purposes. The fruits of *P. minima* var. *indica* are said to form an ingredient in a medicinal oil given for spleen disorders (Dalziel, 432; Sampson, *Kew Bull.*, *Addl Ser.*, No. XII, 1936, 140; Kirt. & Basu, III, 1767; Burkill, II, 1720; Quisumbing, 851; Rama Rao, 285).

Leaf, stem and immature fruits show a positive test for alkaloids (Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 93).

P. peruviana Linn. CAPE GOOSEBERRY

D.E.P., VI(1), 225; Fl. Br. Ind., IV, 238.

HINDI—*Tipari*; BENG.—*Tipariya*; MAR.—*Phopti*; GUJ.—*Moti popti*; TEL.—*Buddabasara*; TAM.—*Tholthakkali*; KAN.—*Gudde hannu*.

PUNJAB & DELHI—*Rasbhary, mewar rashberry*; MAHARASHTRA—*Chirpul, chirboti, tankari.*

An erect branching, densely villous perennial, native of tropical America, introduced into India and other countries and grown both in the plains and hills. Leaves ovate acuminate; flowers with five large purple spots near the base within; berry globose, 2–3 cm. diam., enclosed in the inflated calyx.

The plant is widely grown in India for its edible fruits; the chief source of commercial supply is reported to be Uttar Pradesh, Rajasthan and Punjab; other localities reported are, Poona, Coonoor and Araku Valley (Andhra Pradesh). It is frequently found wild as an escape from cultivation [Naik, 362; Pandit *et al., Indian Fd Packer,* 1960, **14**(4), 16].

The climatic and soil requirements of the cape gooseberry are said to be similar to those of the tomato. The plant favours a warm weather preferably with good rains during the growth period, but a comparatively drier weather is essential at the time of maturing of fruits. It is said to thrive in varying types of soil ranging from sandy loam to laterite. The seeds are small and seedlings are planted when they are about 15–20 cm. high. Planting is best done in September-October. Propagation through one year old shoot cuttings treated with Seradix B_1 is said to have given 37.7 per cent rooting, the most suitable period being March–July. Plants raised from rooted cuttings are said to flower earlier and yield more, but seedlings are said to be more vigorous than cuttings (Khan & Gowder, *S. Indian Hort.,* 1955, **3,** 104; Kuppuswami, ibid., 1954, **2,** 25).

FIG. 17—PHYSALIS PERUVIANA—FRUITS

The plants can be grown pure or as an intercrop in orchards. A basal dressing of about 2.25 kg. of compost or farmyard manure given to each pit at the time of planting is sufficient. Trials at Coonoor have shown that increased application of manure together with irrigation in dry weather result in the improvement of fruit size and yield (Naik, 362; Khan & Gowder, loc. cit.).

Cape gooseberry is said to be subject to very few pests or diseases. A mosaic disease caused by a strain of the tobacco mosaic virus has been reported from commercial plantations near Poona. Affected leaves and fruits are shed. The disease is spread by contact. Cutworms, which may attack the crop in its early stages, may be controlled by application of 0.1 per cent DDT. Mites which may cause defoliation are controlled by regular use of wettable sulphur as sprays (Khan & Gowder, loc. cit.; Capoor & Sharma, *Indian Phytopath.,* 1965, **18,** 58).

The crop matures in about three months after transplanting. In South India, the first picking lasts from January to April; then the bushes put forth new blossom in May and a second picking is possible from July to September. In North India, the fruits are available from January to April, the peak period being February to March. Maturity of the berries is indicated by change of colour of the calyx from green to pale brown or yellowish orange. Fallen berries are said to be more uniform in maturity than handpicked ones. The yield of fruits per plant is said to be about 2–4 kg., the yield per hectare as a rainfed intercrop being 1,650–2,225 kg.; as a pure crop the yield may go up to a maximum of 33,600 kg. per hectare (Naik, 362; Khan & Gowder, loc. cit.; Pandit *et al.,* loc. cit.; Ramasomayajulu, *S. Indian Hort.,* 1953-54, **1,** 145).

As an intercrop the duration of the crop is one year, while as a pure crop it can be extended up to 3–4 years, after which it becomes uneconomical (Khan & Gowder, loc. cit.; Naik, 362).

The fruits are pleasantly acidic with a good flavour and are relished as a table fruit. Analysis of the edible portion (87%) of the fruits gave: moisture, 82.9; protein, 1.8; fat, 0.2; carbohydrates, 11.1; fibre, 3.2; and mineral matter, 0.8%; calcium, 10; magnesium, 31; phosphorus, 67; phytin phosphorus, 18; iron, 2.0; ionisable iron, 0.9; sodium, 0.9; potassium, 320; copper, 0.19; and sulphur, 43 mg./100 g.; acid-base balance (ml. of $N/10$ alkali), 39. The fruits are a good source of carotene and ascorbic acid. They contain: carotene (as vitamin A), 2,380 I.U.; thiamine, 0.05; riboflavin, 0.02; nicotinic acid, 0.3; and ascorbic acid, 49 mg./100 g. Ascorbic acid content varies with maturity of the fruits; unripe fruits from Uttar Pradesh contained 36.5-49.8 mg. and ripe fruits 48.6-53.8 mg./100 g. of ascorbic acid. The presence of a bioflavonoid (possibly kaempferol) is reported in the fresh fruit (Khan & Gowder, loc. cit.; Nutritive Value of Indian Foods, 67, 103, 133; Sinha, *Indian J. appl. Chem.*, 1959, **22**, 32; Ganju & Puri, *Indian J. med. Res.*, 1959, **47**, 563).

A fairly large quantity of gooseberries is reported to be used for making jam in India (Information from Messrs Kissan Products Ltd., Bareilly).

The juice from the ripe fruits contains considerable quantity of pectin. The filtered juice ($d^{22°}$, 1.053) gave the following chemical composition: total solids, 14.4; total ash (mainly potassium and sodium carbonates), 0.97; total acidity (as anhydrous citric acid), 2.2; free glucose, 4.4; and total invert sugars after hydrolysis, 16.97%. The chief acid is citric acid, but malic and tartaric acids are also present (Lal, *Proc. nat. Acad. Sci. India*, 1936, **6**, 309; Winton & Winton, II, 423).

Seeds (*c.* 5% of the weight of husk-free fresh ripe fruits) on extraction with benzene gave 6.3 per cent of a semi-drying and tasteless fatty oil of a pale yellow colour. The oil had the following constants: sp. gr. , 0.881; $[\alpha]_D^{20°}$, $-0.38°$; acid val., 39.1; sap. val., 179.6; iod. val., 120.5; acet. val., 41.58; Hehner val., 93.4; and unsapon. matter, 0.4%. The fatty acid composition showed: palmitic, 6.6; stearic, 5.4; arachidic, 0.1; oleic, 42.4; and linoleic acid, 37.5%. The alcoholic extract of the seeds contains an amorphous saponin and glucose (Gupta & Lal, *Proc. nat. Acad. Sci. India*, 1937, **7**, 131).

The husk of the fruits has a bitter taste. It contains a mixture of potassium chloride and potassium citrate (0.15%), a phytosterol ($C_{27}H_{44}O.H_2O$, m.p. 132°), a bitter amorphous glucoside ($C_{45}H_{66}O_{18}$, m.p. 100–02°), trace of a pungent alkaloid, tannins and phlobaphenes (Lal, *Proc. nat. Acad. Sci. India*, 1938, **8**, 59).

Leaf contains chlorogenic acid. Leaf infusion is used in abdominal disorders. The heated leaf is applied as a poultice (*Chem. Abstr.*, 1948, **42**, 4649; Kirt. & Basu, III, 1769).

P. virginiana Mill. var. *sonorae* (Torr.) Waterfall syn. *P. longifolia* Nutt., a native of America, is reported to have been introduced and naturalized in the coastal parts of Andhra Pradesh, Maharashtra and Gujarat and also in Kerala and Punjab (Santapau *et al.*, *J. Bombay nat. Hist. Soc.*, 1961, **58**, 550).

Physic Nut — *see* **Jatropha**

PHYSOCHLAINA G. Don (*Solanaceae*)

A small genus of herbs distributed in Central Asia. One species occurs in India.

P. praealta (G. Don) Miers

D.E.P., VI(1), 226; Fl. Br. Ind., IV, 244; Kirt. & Basu, Pl. 687C.

PUNJAB—*Sholar, bajar-bang, nandru, dandarwa*; LAHUL—*Laltang*; LADAKH—*Lang thang*.

An erect, nearly glabrous perennial herb 60–150 cm. high, found in Lahul valley (Punjab), Ladakh, North Kashmir and western Tibet at altitudes of 3,300–4,650 m. Leaves irregular, ovate-oblong, wavy; flowers greenish, campanulate, in terminal corymbose cymes; capsules 2-celled; seeds many, scrobiculate-reticulate.

P. praealta grows wild and in abundance in Ladakh and Lahul. The plant constitutes an excellent source of atropine which, at present, is being imported from abroad. As the plant grows in Ladakh at high altitudes (3,300 m.), its exploitation becomes uneconomical because of high cost of collection and transportation. In Lahul sub-division, the plant occurs commonly as a weed on boundaries of fields and roadsides. The plant flowers in June, and seeds mature in September–October after which the aerial portions die. The plant remains dormant under the snow and sprouts out next spring. Being a perennial, leaves can be gathered more than once in a year. Leaves should be collected when plants are in full bloom towards the end of June and spread open in thin layers for drying in the sun. It is estimated that nearly 15 tonnes of dried leaves can be gathered annually from Lahul, if systematically collected. The plant can be successfully grown by transplanting seedlings raised from seeds sown in March. Experi-

FIG. 18—PHYSOCHLAINA PRAEALTA—FLOWERING BRANCH

mental cultivation at Srinagar (1,500 m.) showed that the plant did not attain the full size of its natural habitat in Ladakh and Lahul and the growth was rather stunted (Chopra, *J. sci. industr. Res.*, 1952, **11A**, 241 ; Kapoor *et al.*, ibid., 1953, **12A**, 315 ; Sarin *et al.*, *Indian For.*, 1963, **89**, 610).

The pharmacological activity of the plant is due to the presence of hyoscyamine. The leaves are a good source of hyoscyamine for subsequent conversion into atropine ; racemization of hyoscyamine with alkalies yields atropine. The dried leaves collected from plants growing in Leh (Ladakh) contain over 1.0 per cent alkaloids, mainly hyoscyamine and minor amount of hyoscine ; fairly large amounts of potassium salts are also present. The alkaloidal content of the leaves of the plant from Lahul has been found to be 0.88 per cent, calculated as hyoscyamine. The alkaloidal yield from the leaves from Srinagar was low (0.16–0.24% in the first and 0.74% in the second year) compared to that obtained from plants growing in Ladakh and Lahul. Roots of the plants contain 0.64 per cent alkaloids (calculated as hyoscyamine) and about 8 per cent sucrose (Chopra *et al., Res. & Ind.*, 1956, **1**, 106 ; Handa *et al., J. sci. industr. Res.*, 1951, **10B**, 182 ; Handa, ibid., 1951, **10B**, 234 ; Handa & Channa, ibid., 1952, **11B**, 505 ; Sarin *et al.*, loc. cit. ; Kapoor *et al.*, loc. cit.).

The leaves of the plant are narcotic and possess mydriatic properties causing dilatation of the pupil of the eye, as belladonna. The leaves are also said to be poisonous ; the head and throat are affected when they are eaten, and the mouth swells when touched by leaves. The leaves are applied to boils. Seeds are used by local people as vermifuge to expel roundworms, and as an emetic in bilious attack (Kirt. & Basu, III, 1793 ; Chopra *et al., Bull. nat. Inst. Sci. India*, No. 4, 1955, 25).

The leaves are harvested and dried as winter fodder for livestock, but they are considered poisonous to man, horses and ponies. Some plants develop black fungal growth (sclerotia) on the stem and are said to be highly poisonous to all types of animals (Chopra *et al., Bull. nat. Inst. Sci. India*, No. 4, 1955, 25 ; Abrol & Chopra, *Curr. Sci.*, 1962, **31**, 324).

PHYSOSTIGMA Balf. (*Leguminosae ; Papilionaceae*)

A very small genus of climbers distributed in tropical Africa. *P. venenosum*, the source of Calabar Bean used in medicine, does not occur in India, but is reported to have been introduced. The chief source of supply is said to be Sierra Leone.

P. venenosum Balf. CALABAR BEAN, ORDEAL BEAN

Irvine, 1961, 402, Fig. 85.

A climber, woody at base, 6 m. or more high, indigenous to West Africa. Its cultivation may be tried in the plains of South India on the banks of streams near sea coast and in the Nilgiris, and several other States. Leaves trifoliolate ; leaflets ovate, acuminate ; flowers purple, shell-shaped, in axillary drooping racemes ; fruits 15 cm. × 5 cm., narrowed at ends, yellowish brown ; seeds few, ellipsoid, over 2.5 cm. long, one side nearly straight, the other grooved by depressed hilum (Nayar & Chopra, 39).

Calabar beans are odourless with starchy taste at first and acrid afterwards. The beans are extremely poisonous causing paralysis of lower limbs and death by asphyxia, and in large doses, paralysis of the heart. They were formerly used in Calabar as an ordeal poison and so their cultivation and sale was forbidden in the African territories. The poisonous principle in the seed is destroyed by boiling and scorching the

seed (U.S.D., 1955, 1054; Dalziel, 256; Irvine, 1961, 402).

The dried seeds contain 0.18–0.25 per cent of alkaloids, mainly physostigmine (eserine; 5-ethoxy-1:3-dimethyl-3-ethyl-2-indolinolone, $C_{15}H_{21}O_2N_3$; m.p. 86–87° and 105–06°, the latter form being more stable), with minor amounts of related alkaloids. By selective cultivation, it is possible to increase the alkaloid content. Physostigmine is the active principle of the drug and its salicylate (m.p., 184–87°) is official in I.P. and B.P. Physostigmine salicylate is used mainly in ophthalmology to reduce intraocular tension in glaucoma and to correct the dilatation of the pupil caused by mydriatics. It has been used in post-operative distension and atony of the intestines or urinary bladder, and in tetanus, strychnine and atropin poisoning. In the treatment of myasthenia gravis, it has been largely replaced by neostigmine. It is also useful as an antispasmodic in rheumatoid arthritis, fibrositis and bursitis. It is often used in veterinary medicine for colic in horses (Henry, 539–48; Sinha, *J. Instn Chem. India*, 1959, **31**, 211; U.S.D., 1955, 1055–56; I.P., 478; B.P., 1963, 613; B.P.C., 1963, 620; B.V.C., 283).

The beans are used in Africa for killing mice; the beans, crushed and mixed with palm oil, are used as a remedy for lice. The crushed seeds are used for local applications in parasitic skin diseases (Dalziel, 256; Irvine, 1961, 404).

The stems of the plant are split into layers and used as mats for drying cocoa. Leaves yield a black dye used to dye wood black (Irvine, 1961, 402).

PHYTELEPHAS Ruiz & Pav. (*Palmae*)

Blatter, 546, Pl. CIV & CV.

A very small genus of stemless or low-stemmed palms, native to South America. One species, *Phytelephas macrocarpa* Ruiz & Pav. (IVORY NUT PALM, TAGUA PALM), a slow growing, dioecious palm with handsome, pinnate leaves, is cultivated in some gardens in India. It bears a bunch of 6–7 fruits, each fruit containing 6–9 seeds, about the size of a hen's egg.

The young and maturing endosperm of the seed is sweet and edible. When mature, the endosperm becomes horny and has the appearance of ivory and is used as a substitute for the latter in the manufacture of buttons, toys and other fancy articles. Its tissue is said to take dye well. The refuse from turnery can be utilized as animal feed. The endosperm contains 60 per cent mannan and on hydrolysis provides a good source of mannose. The pale brownish covering enclosing the seeds yields 35–38 per cent of an edible oil of semi-solid consistency (Acosta-Solis, *Econ. Bot.*, 1948, **2**, 46; Hill, 240; Burkill, II, 1722; Winton & Winton, II, 386–88; Whistler & Smart, 152; Oilar, *J. Amer. Oil Chem. Soc.*, 1954, **31**, 142).

The apical cone is eaten as a cabbage. The leaves are used for thatching and fibres of the spathe for making ropes. The roots are used medicinally (Acosta-Solis, loc. cit.).

PHYTOLACCA Linn. (*Phytolaccaceae*)

A genus of herbs and shrubs, sometimes climbers, or rarely trees, distributed in the tropical and subtropical regions. The genus is chiefly confined to America with a few species occurring in Africa and Asia; several ornamental species are cultivated in Europe and elsewhere. Four species occur in India.

P. acinosa Roxb. SWEET BELLADONNA, INDIAN POKE

D.E.P., VI(1), 226; Fl. Br. Ind., V, 21 in part; Coventry, Ser. I, Pl. XLI.

HINDI—*Matazor, sarangun.*

KASHMIR—*Lubar sag;* PUNJAB—*Lubar, rinsag;* KUMAUN—*Jarak, jirrag;* ASSAM—*Jaiong.*

A succulent, robust, perennial herb, up to 1.5 m. high, occurring both in a wild and cultivated state in the temperate Himalayas from Kashmir to Bhutan and in the hills of Assam at altitudes of 1,000–3,000 m. Leaves elliptic-ovate or lanceolate; flowers whitish, greenish or pinkish in opposite or terminal racemes; fruit purple or black, consisting of *c.* 10 single-seeded, nearly free carpels; seeds kidney shaped, blue-black.

Tender leaves and twigs are cooked as vegetable. The herb is believed to have a narcotic effect, which is destroyed on boiling. The fruit is occasionally eaten and used as a flavouring. It is not uncommon for the local people to mistake *Atropa acuminata* (INDIAN BELLADONNA) for *P. acinosa*, resulting in serious food poisoning; for the same reason roots and leaves of *P. acinosa* have been found mixed in belladonna consignments exported from India (Hedrick, 434; Chaudhri, *Pakist. J. Sci.*, 1957, **9**, 1; Khanna & Atal, *J. Pharm., Lond.*, 1960, **12**, 365).

Seed kernels gave a yellow fatty oil having the following values: sp. gr.$^{15°}$, 0.915; $n_D^{20°}$, 1.4713; sap. val., 186; iod. val., 105; and unsapon. matter, 1.5–2.0%. The fatty acid composition shows 8 per cent of saturated and 92 per cent of unsaturated acids. A

toxic principle phytolacca-toxin, resembling picrotoxin, is isolated from the seeds (Mensier, 446).

P. dioica Linn., a shrub or a tree with drooping racemes of white flowers and purple fruits, is a native of South America. It has been introduced in some of the Indian gardens, and is met with as an escape in the Nilgiri and Kodaikanal hills. The tree grows rapidly, attaining a height of 15 m. or more, and is useful both for shade and ornament. In Queensland, its leaves are used as fodder in times of drought. The leaves contain saponins and their infusion acts as a purgative. Two glycosides, rutin and dimethyl rutin, have been isolated from the leaves. Dimethyl rutin has high tinctorial properties and dyes wool in different shades of yellow. The fruit is said to be poisonous. The wood contains tannin (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 12 ; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 126 ; *Chem. Abstr.*, 1953, **47,** 12376 ; 1955, **49,** 309 ; 1951, **45,** 614 ; Record & Hess, 425 ; Watt & Breyer-Brandwijk, 836).

Piassava — *see* **Raphia**

PICEA A. Dietr. (*Pinaceae*)

A genus of tall, evergreen trees, commonly known as Spruce, distributed in the temperate and cooler regions of the northern hemisphere from the Arctic circle to the high mountains of warm temperate regions. Three species occur wild in India, and two exotics are being acclimatized in the western Himalayas.

Many of the spruces yield light and soft woods, which are elastic and possess a high strength/weight ratio. *P. abies* Karst. syn. *P. excelsa* Link (European Spruce, Norway Spruce) is an important timber tree and pulpwood of Europe ; *P. sitchensis* Carr. (Sitka Spruce) is a very useful timber tree of the north-western coast of North America ; *P. smithiana* Boiss. is a good source of timber in the western Himalayas ; and *P. asperta* Mast., widely distributed in western China, is the Asian counterpart of the European spruce (Streets, 448–65).

The applications of the spruce woods are numerous including light interior construction work, mill-work, cooperage, rough furniture, and match-boxes. The woods of many *Picea* spp. are resonant, and are used for musical instruments, such as sounding boards of pianos and bodies of violins. Paper and fabric pulps are also manufactured from spruce woods. Waste from spruce woods may provide material for the production of synthetic rubber. Spruces are also valued for ornamental purposes ; hundreds of them are felled during Christmas for use as Christmas-trees (Hill, 95 ; Dallimore & Jackson, 384 ; *Sci. News Lett., Wash.*, 1950, **58,** 165).

P. smithiana Boiss. syn. *P. morinda* Link ; *Abies smithiana* Lindl. West Himalayan Spruce

D.E.P., I, 3 : VI(1), 227 in part ; Fl. Br. Ind., V, 653 in part ; Troup, III. Fig. 477–80.

N. W. Himalayas—*Rai, rau, re, riar, kachal, kachhlu, salla, tos ;* Jaunsar, Garhwal & Kumaun—*Roi, rhai, ragha, kathela, kandre, morinda.*

Trade—*Spruce.*

A very tall tree, reaching up to 60 m. or more in height and 7 m. in girth, but usually much smaller, found in the Himalayas from Kashmir to Kumaun at altitudes of 2,000–3,500 m., descending to about 1,500 m. in some localities. In close forests, the trees have a clean bole up to 21 m., but more often they bear branches from about 9 m. upwards. Branches whorled, spreading or drooping, with slender pendulous branchlets ; bark brownish grey, furrowed,

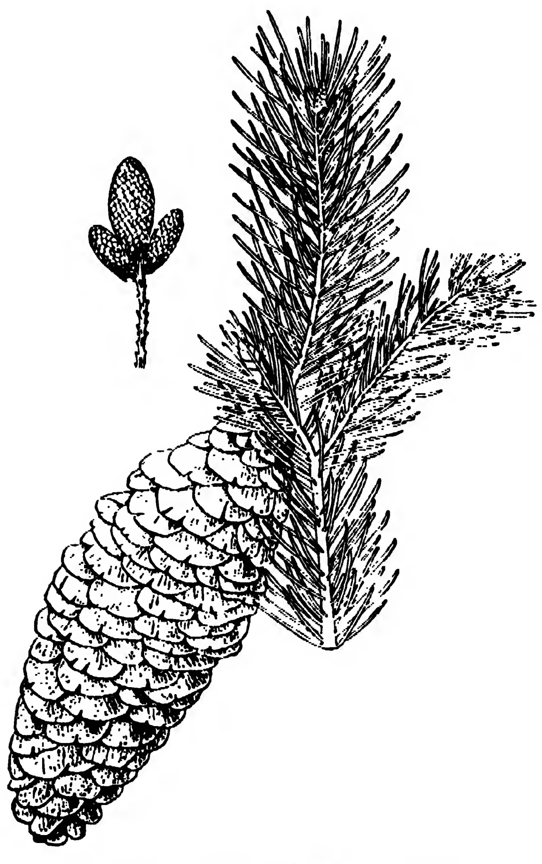


FIG. 19—PICEA SMITHAIANA—FRUITING BRANCH

exfoliating in small scales; leaves dark green, spreading all round the shoots, incurved, needle-like, 2.5–3.8 cm. long, with peg-like leaf bases, 4-sided, persisting in part for a number of years; male flowers monoecious, axillary, catkin-like, greenish yellow, elongating considerably after shedding the pollen; female cones solitary terminal, ripe cones cylindric-ovoid, 10.0–15.0 cm. × 2.5–5.0 cm. or more, dark brown, pendent from the ends of the branches; seeds ovoid, 4–5 mm. long, dark brown with obliquely spathulate 10–15 mm. long wing.

Although a gregarious tree, it is seldom found pure over large areas. It is associated with *Abies pindrow*, *Cedrus deodara* and *Pinus wallichiana*, and a number of broad-leaved trees, such as *Aesculus indica*, *Juglans regia*, *Prunus cornuta*, and species of *Quercus* and *Acer*. It occurs on various geological formations, the most common being mica schist, shale, gneiss and limestone. Climatically, it belongs to cool temperate regions of the Himalayas with a heavy snowfall and a total annual precipitation of 100–250 cm.; the maximum shade temperature in its natural habitat seldom reaches 32° (92°F). Owing to its pendulous branchlets, spruce is not so subject to snow-breaks as deodar or blue pine. The spruce requires certain amount of shade in the early stages, but once established, complete overhead light is necessary for optimum development. It has a more or less superficial root system, and is not wind-firm (Troup, III, 1144, 1147).

Natural regeneration –It takes place through the seeds, which get dispersed in October–November when the cones ripen; the cones take six months after pollination to ripen. The trees begin to bear cones from the age of about 20 years, moderate sized trees, 1.0–2.5 m. in girth, bearing the maximum number of cones. Each cone yields about 300 seeds. Even though good seed-years occur after comparatively long intervals of 3–4 years, quite a good quantity of seed is produced in other years. The seeds begin to germinate during June–July of the following year, the germination period continuing up to September. The chief requirements for successful regeneration, in addition to abundance of overhead light are: (*i*) recently exposed mineral soil, (*ii*) protection from recurring fires, indiscriminate grazing, and desiccating effect of the sun, and (*iii*) freedom from dense weed growth. Fire plays havoc in a spruce forest, but in regenerative operations it also plays a useful role in preparing the ground for germination of the seeds by consuming the debris and raw humus;

F.R.I., Dehra Dun

FIG. 20—PICEA SMITHIANA

in the spruce forests the ground vegetation is generally very dense and the seeds often fail to reach the soil. The germination percentage is about 42 (Troup, III, 1148–49; Kaushik, *Indian For.*, 1954, **80**, 78; Gamble, 717).

Under natural conditions an average annual height-growth of about 2.5 cm. for the first five years is usual, the growth thereafter increasing to about 5.0–7.5 cm. per annum for a few years. Ring countings have indicated an annual girth increment of 1.3–1.5 cm. (Troup, III, 1147; Gamble, 717).

Artificial regeneration—The spruce may be grown either by direct sowing or by transplanting nursery-grown seedlings. Fresh seeds are sown in the nursery in October–November. Germination commences towards the end of the following May or in June and continues during July–August. Germination percentage of seeds is 76, as the drought factor is eliminated. The seedlings are pricked out in the nursery when two years old and planted out at site at the age of three or four years, care being taken to avoid injury to the roots and their exposure to the sun. The plants to be transplanted are bundled together and

TABLE 1—GROWTH IN GIRTH AND HEIGHT OF P. SMITHIANA*

Age in years (from seed)	Mean girth (cm.)	Mean height (m.)
8	7.11	0.85
10	8.38	1.07
12	9.70	1.31
14	11.68	1.62
16	13.72	1.98
18	..	2.38
20	..	2.89

* Troup, III, 1151.

their roots covered with damp moss. The nursery-grown seedlings show a yearly average height-growth of 5.0–7.5 cm. during the first few years. In other countries, debudding of young plants has proved useful in producing knot-free timber. Measurements of growth in girth and height, made at different times in plantations at Jaunsar, are given in Table 1 (Troup, III, 1147, 1150–51; Kaushik, loc. cit.; *Indian For.*, 1952, **78**, 358).

Diseases and Pests—A large number of fungal diseases and insect pests have been recorded on spruce, but detailed surveys regarding the extent of damage they cause in forests have not been carried out. Among fungi causing rot or decay are *Armillaria mellea* Quel. and species of *Collybia, Fomes, Lenzites, Merulius, Polyporus, Polystictus, Poria, Stereum* and *Trametes,* whereas needle rust is caused by species of *Chrysomyxa* and *Peridermium.* Among insects, species of *Calochromus*, *Dryocoetes*, *Pityogenes*, *Polygraphus* and *Xenomimetes* bore into the bark or fallen wood, and those of *Eucosma* and *Euzophera* into the cones. *Adelges* (*Dryfusia*) *himalayensis* Stebb. syn. *Chermes abietis-piceae* Stebb., an aphid, causes malformation of needles into gall-like pseudocones which contain these insects instead of ovules and should not be confounded with catkins and cones [Troup, III, 1146, 1148; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 276; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 26].

Silvicultural management of the spruce has been linked with that of the Himalayan silver fir, its most common associate under "fir forests", which are generally worked by selection system. The two species, however, differ widely in their ecological and silvicultural characters to be linked together and it has been suggested that the Punjab shelterwood compartment system which permits modification in principles of regular or shelterwood compartment system would be suitable for pure or dominantly spruce forests. For fuel purposes spruce trees of about 40 years of age with a girth of about 0.9 m. may be felled, but for procuring timber as well as fuel the exploitable age of the trees is about 100 years, when they have a girth of about 1.9 m. For timber purposes, therefore, a rotation of 100–120 years is needed, although it is reported that in actual working a period of 80–90 years will be more useful and hasten the replacement (Kaushik, loc. cit.; Gamble, 717).

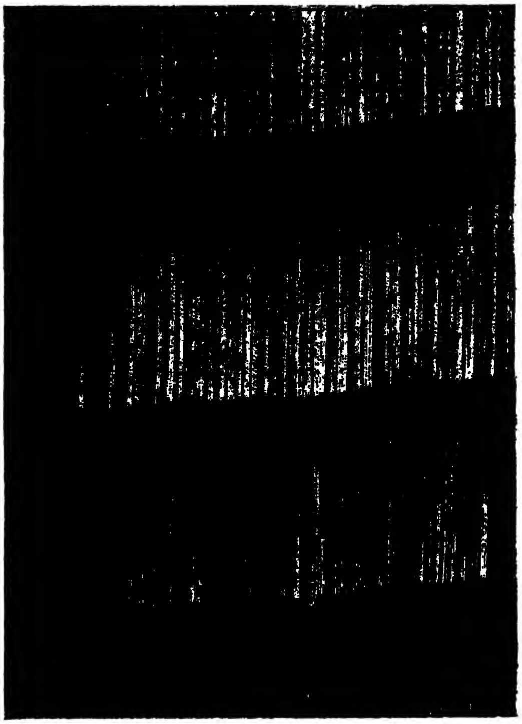
Spruce is one of the most useful timber trees of the western Himalayas. Kashmir has the most extensive spruce forests, and the timber from these areas is obtained in the form of sleepers, beams and logs. The timber from Kangra and Kulu forests is floated down the river Beas to Dhilwan (Punjab) in the form of sleepers. The spruce wood, available in the Simla hills, is of good quality, but there are transportation difficulties. The Kalatope forests, near Dalhousie, produce a considerable quantity of timber, most of which is utilized locally. A small quantity of timber is also available from Chakrata division (U.P.). Spruce forests in the Tehri-Garhwal area are also a good source of timber, which is marketed at Hardwar on the bank of the Ganges, and at Jagadhri close to the Yamuna Canal. The timber from Kashmir forests is the cleanest while that obtained from Simla (catchment area) gives the highest strength values. In the timber markets of northern India, spruce wood is not discriminated from that of the silver fir, woods from both the species being marketed under the common name *Partal.* It is, therefore, difficult to estimate the outturn of each species separately. However, spruce wood can be distinguished by the presence of resin canals, which are absent in the wood of silver fir [Limaye, *Indian For. Rec., N.S., Util.*, 1942, **2**(7), 168; Chowdhury, *For. Bull., Econ. Ser.*, No. 84, 1934, 14].

Spruce wood is white, turning brownish with age, straight- and even-grained, medium fine- and quite even-textured, relatively strong for its weight, stiff, soft, and light (av. sp. gr., 0.48; av. wt., 481 kg./cu.m.). There is little differentiation between sapwood and heartwood, but in large trees a dull-red core, frequently of considerable diameter, may be found at the base. This red-wood, simulating the heartwood, is of a different character from the white-wood. In the past it was thought that the red-wood

becomes waterlogged when floated down the rivers, thus considerably diminishing the total out-turn of spruce timber. Experiments have, however, shown that the red-wood (properly dried for 8–10 months), though heavier, has less water absorbing capacity than the normal white-wood, and properly dried red-wood sleepers can be floated down the rivers like any other timber without any extra loss. The red-wood, which is simply the darker denser material, if taken from healthy trees, is in no way inferior to the white-wood (Pearson & Brown, II, 1053–54; Khan, *Indian For.*, 1919, **45**, 496; Aggarwal, ibid., 1932, **58**, 628; ibid., 1927, **53**, 535).

The wood is easy to season, but develops fine long splits if exposed to direct sun in the green state. Logs should be converted immediately after felling and the material open-stacked well off the ground to prevent fungal attack, which is a greater danger than seasoning defects. Kiln-drying presents no difficulty; 2.5 cm. thick planks take 4–5 days to season and require an initial steaming for about 2 hours at 55°/100 per cent R.H. for sterilization and killing the mould growth. Spruce wood is not durable in the open and moderately so under cover; graveyard tests indicated a natural durability of 2–5 years. It is a difficult wood to treat with preservatives even under pressure; incision is necessary for 1.3–1.9 cm. penetration. The wood is easy to saw and work, but quite often the presence of an excessive number of large knots detracts from its value as a carpentry wood. It is not very satisfactory for rotary cut veneer; the fibres tear up along the annual rings during the peeling process. It takes varnish well, but darkens considerably on exposure. It does not offer any difficulty in gluing. The data for the comparative suitability of the timber, expressed as percentage of the same properties of teak, are: wt., 70; strength as a beam, 65; stiffness as a beam, 80; suitability as a post, 70; shock-resisting ability, 70; retention of shape, 70; shear, 75; and hardness, 50 (Pearson & Brown, II, 1055; Trotter, 1944, 149; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Rehman, ibid., 1953, **79**, 372; Narayanamurti, *Comp. Wood*, 1956, **3**, 51; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 56, Sheet No. 15; IS: 399, 1952, 5).

The wood is used for planking, general fittings and joinery, rough furniture, tea boxes, and packing cases; it is one of the best light boxwoods in India. Large quantities of timber after treatment are used for railway sleepers. The wood is suitable also for match-boxes, battery-separators and, after treatment,



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 21—PICEA SMITHIANA—TRANSVERSE SECTION OF WOOD (×10)

for fence posts, transmission poles and piles. Although the wood has not been found to be suitable for spars and longerons of the aeroplanes, as knot-free long lengths of timber are not available, it is equal or sometimes even superior to the sitka spruce wood for other aircraft items, where small lengths are required. The wood of *P. smithiana* is also suitable for the manufacture of newsprint and cheap printing and writing papers. It contains 47.2–49.4 per cent of cellulose and yields a long-fibred pulp (av. fibre length, 3.4 mm.; av. diam., 32μ). The wood is suitable for the preparation of wood meal for certain explosives. It is also a good fuel wood (cal. val., 4,967 cal., 8,941 B.t.u.), and is much in demand for charcoal [Pearson & Brown, II, 1055–56; Trotter, 1944, 150; Rehman & Jai Kishen, *Indian For. Bull., N.S.*, No. 147, 1950, 16; Narayanamurti, loc. cit.; *J. Timb. Dryers' & Pres. Ass. India*, 1956, **2**(3), 16; Limaye, *Indian For. Rec., N.S., Util.*, 1942, **2**(7), 171; *Indian For.*, 1941, **67**, 474; 1952, **78**, 349; Deshpande, *Indian Pulp Pap.*, 1955–56, **10**, 57; Dhingra *et al.*, *J. Sci. & Technol.*, 1949, **9**, 94; *For. Res. India*, 1941–42, pt I, 79; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21].

The fresh leaves and terminal branches, collected in October from the Jubbal hills of Himachal Pradesh, gave on steam distillation a pale-yellow essential oil (0.21%) with a pleasant odour. It has the following physico-chemical characteristics: sp. gr.$^{16°}$, 0.8809; $n_D^{16°}$, 1.4799; $[\alpha]_D^{16°}$, +12.5°; acid val., 11.74; ester val., 50.44; and ester val. after acetylation, 72.19. The oil contains: α-pinene, *l*-α-phellandrene, dipentene, bornyl acetate, cadinene, S-guaiazulene and an unidentified bicyclic sesquiterpene. The oil distilled from the leaves collected in Gulmarg had an ester content of 23.2 per cent (as bornyl acetate) and was soluble in all proportions of 90 per cent alcohol. The oil of *P. smithiana* resembles that of the European spruce and may be used in pine compositions such as bath salts, room sprays and deodorants. The leaves also contain an alkaloid. They are reported to be used as manure and as litter for cattle. They are found to be suitable as activators for making sawdust boards. Bark contains 4.22 per cent tannin. A tonne of bark yields about 227 kg. of extract [Rao & Sood, *Soap Perfum. Cosm.*, 1962, **35**, 527; Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 25; *Chem. Abstr.*, 1956, **50**, 13372; Narayanamurti *et al.*, *Res. & Ind.*, 1962, **7**, 63; Tej Singh *et al.*, *Indian For.*, 1958, **84**, 574; *Bull. cent. Leath. Res. Inst., Madras*, 1961–62, **8**, 255].

P. brachytyla (Franch.) Pritzel syn. *Abies brachytyla* Franch. is a medium-sized tree, sometimes up to 30 m. in height, found in the N.E.F.A. area of Assam at an altitude of about 3,500 m. The timber has been extensively exploited in China, and is reported to be used for constructional purposes in N.E.F.A. (Sahni, *Indian For.*, 1962, **88**, 748).

P. spinulosa (Griff.) Henry syn. *P. morinda* Hook. f. (Fl. Br. Ind.) in part, non Link, *Abies spinulosa* Griff., *P. morindoides* Rehd. (Sikkim Spruce) is a very tall tree, sometimes attaining a height of over 60 m., but usually much smaller, found in Sikkim, Bhutan, and Mishmi hills of Assam at altitudes of 2,400–3,300 m. It resembles *P. smithiana* in general habit but differs from it in having flat leaves. The wood is very similar in appearance to that of *P. smithiana* but is said to be harder and heavier. The wood yields 45 per cent bleached pulp (av. fibre length, 2.8 mm.; av. diam., 27μ), used for writing and printing paper (Raizada & Sahni, *Indian For. Rec., N.S., Bot.*, 1958, **5**, 120; Dallimore & Jackson, 440; Man Mohan Singh & Mukherjea, *Indian For.*, 1965, **91**, 505).

The two introduced species are *P. abies* Karst. and *P. sitchensis* Carr. Experimental trials for introduction of *P. abies* at Manali (alt., 1,890 m.) have recorded a fair amount of growth for the last 30 years. It is reported that treatment of seeds with strong doses (1–100 mg./l.) of heteroauxin hastens their germination. Besides timber, *P. abies* also yields an oleo-resin, which is purified into the medicinal Burgundy Pitch, used as a stimulant and counter-irritant in plasters and ointments. The leaves, twigs, buds and cones yield essential oils, used in perfumes and cosmetics. The seeds give a fatty oil, employed in varnishes. The bark yields tannin (*For. Abstr.*, 1950–51, **12**, 455; Claus, 1961, 274; U.S.D., 1947, 1374; Gildemeister & Hoffmann, IV, 167; Hoppe, 668).

The trials to introduce *P. sitchensis* at Kulu (alt., 2,500–2,700 m.) have not shown much success. It yields the most valuable of all spruce woods, which has been in great demand for aircraft construction. The timber is available in long dimensions; it is possible to have planks up to 12 m. in length (Dallimore & Jackson, 435).

PICRASMA Blume (*Simaroubaceae*)

A small genus of trees and shrubs distributed in tropical and sub-tropical regions. Three species occur in India.

P. javanica Blume

Fl. Br. Ind., I, 520.

Nepal—*Teju*; Assam—*Bonposhla, nimtita*; Garo—*Bor-jagreng*; Mikir—*Sheng-lokso*; Naga—*Aeo*; N.E.F.A.—*Putichhal*; Lepcha—*Tungchir*.

A moderate-sized tree found in Assam and Khasi and Aka hills, Kalahandi (Orissa) and the Andaman Islands. Bark thin, dark brown or black, smooth; leaves imparipinnate with oblong, ovate elliptic or obovate-oblong leaflets: flowers polygamous, dull white or green, in axillary panicles: fruit a fleshy sub-globose drupe, white or black when ripe, shining.

The bark of the plant is exceedingly bitter and is used as a febrifuge. It contains a bitter principle allied to quassin. In Java, the leaves are applied to sores (Burkill, II, 1723; Kirt. & Basu, I, 510; Nadkarni, I, 952).

P. javanica var. *nepalensis* (Bennett) Badhwar syn. *P. nepalensis* Bennett (Nepal—*Teju*; Garo—*Thigisin*) is a tree, 6–12 m. high, with elliptic-lanceolate or obovate-oblong leaflets and dull white flowers and sub-globose, black drupes, found in Nepal, North Bengal and Khasi, Aka and Garo hills in Assam.

Powdered young leaves and twigs of the plant are reported to be used as larvicide in Assam (Chopra, 1958, 581).

P. quassioides Bennett

D.E.P., VI(1), 227; Fl. Br. Ind., I, 520; Kirt. & Basu, Pl. 205.

HINDI—*Bharangi, charangi, kashshing;* BENG.—*Bhurungi.*

PUNJAB—*Hala, puthorin, tithu;* KUMAUN—*Karwi;* NEPAL—*Shamabaringi;* KHASI—*Dieng-khlang.*

A large shrub or small tree, attaining a height of 12 m. and a girth of 1.2 m., found in the sub-tropical Himalayas from Jammu to Nepal, Bhutan, and Khasi and Naga hills ascending to altitudes of 900–2,500 m. Bark light brown, rather smooth; leaves imparipinnate: leaflets ovate to lanceolate, serrate; flowers green, in axillary corymbose panicles; drupes about the size of a pea, black when ripe, each containing one seed.

The wood of *P. quassioides* closely resembles commercial Quassia (Jamaica Quassia from *P. excelsa*) in general appearance, microscopic structure, taste and medicinal properties. It is official in the I.P. and recognized as Quassia and has been recommended as an efficient substitute for Jamaica Quassia. The wood contains quassin, the concentration of bitter principles being 0.31 per cent. In addition, it contains a bitter alkaloid (0.05%) and a bitter fluorescent substance (0.15%), which act as adjuvants to quassin and enhance the potency of the drug. The wood (wt., 513 kg./cu.m.) is bright yellow, moderately hard and takes polish. It is used in Japan for mosaic work and utensils (Chopra, 1958, 218; I.P., 513–14; Gamble, 133; Uphof, 278).

The bark and leaves of the plant are used in Punjab as a febrifuge and as an insecticide. Leaves are applied to itch. A decoction of bark is used to kill flea in cattle (Chopra, 1958, 217–18; Kirt. & Basu, I, 510; Cheo, *Bot. Bull. Acad. sinica,* 1947, **1**, 304).

The fruit is eaten in certain localities. Seeds yield a fatty oil (Nigaki Oil) consisting of 23 per cent of saturated and 77 per cent of unsaturated (mostly petroselinic) acids. A sample of oil obtained from seed shells contains palmitic acid as the chief constituent. The fruit is used as stomachic. The plant is said to be browsed by goats and sheep (Hilditch, 1956, 219, 249; Wehmer, suppl., 155; Hoppe, 671).

P. excelsa (Sw.) Planch. syn. *Picraena excelsa* Lindl., a moderate-sized tree, 12–18 m. high, with a straight trunk, 60 cm. or more in diam., indigenous to the West Indies, is recommended to be grown in India for its wood used in medicinal preparations. Its cultivation may be tried in the sub-tropical belt of the Himalayas from Jammu to Nepal at altitudes of 900–1,800 m. Bark smooth, whitish; leaves pinnate with oblong pointed leaflets; flowers small, greenish white, in panicles; fruit a small, black berry (Nayar & Chopra, 39).

The bitter quassia, which is the dried stem wood of this plant is known in commerce as Jamaica Quassia, whereas *Quassia amara* Linn. (q.v.) furnishes the Surinam Quassia of trade. Previously quassia was obtained exclusively from *Q. amara;* it has now been replaced in England and America by *P. excelsa.* Surinam quassia wood is still used in the continental Europe. Quassia obtained from both the plants are identical in their appearance, structure of wood, chemical composition, medicinal and insecticidal properties and uses. Quassia occurs as logs, transverse slices, chips, raspings or shavings and occasionally in billets; it is pale to bright yellow, light, rather dense and tough, but easily splits longitudinally. It is odourless and has an intensely bitter taste (Chopra, 1958, 218; B.P.C., 1963, 690–91; U.S.D., 1955, 1152; Youngken, 507; Holman, 133).

Quassia owes its activity to the presence of bitter amaroids, namely quassin, *iso*quassin (picrasmin, $C_{22}H_{28}O_6$, m.p. 222–25°), and neoquassin ($C_{22}H_{30}O_6$, m.p. 229–31°); quassin has been found to be a molecular complex of the ketone *iso*quassin and the alcohol neoquassin. The drug contains up to 0.48 per cent of total bitter principles, besides minute quantity of a yellow crystalline alkaloid exhibiting blue fluorescence in acidified alcoholic solution. Preliminary clinical trials have indicated quassin to be a promising substitute for emetine hydrochloride (B.P.C., 1963, 690; Adams & Whaley, *J. Amer. chem. Soc.*, 1950, **72**, 375; Chopra, 1958, 218; U.S.D., 1955, 1153).

Quassia is used as a non-astringent bitter tonic and stomachic and, in the form of enema, as an anthelmintic for the expulsion of thread worms. It is given in the form of infusion, tincture, extract or fluid extract (B.P.C., 1963, 691; Wallis, 61; Steinmetz, II, 371; U.S.D., 1955, 1153).

It is now chiefly used as an insecticide and forms an important ingredient in proprietary medicines and in "conditioning powders" for domestic animals; it is used in the manufacture of non-poisonous fly-papers. It is used as substitute for hops to add bitterness in the brewing of ale and porter. Quassia wood

is said to be used in Jamaica for ceilings, bedsteads and presses (Holman, 133).

Quassia bark obtained from *Picrasma excelsa* and *Quassia amara* is used in medicine and probably contains principles similar to those found in quassia wood (Claus, 1961, 157).

PICRIS Linn. (*Compositae*)

Fl. Br. Ind., III, 392.

A genus of annual or perennial herbs distributed in the Mediterranean region, temperate Europe, and temperate Asia. One species has been recorded in India.

P. hieracioides Linn. is an erect coarse herb, 30–120 cm. high, with sinuate-toothed radical leaves and entire half-amplexicaul cauline leaves, and numerous terminal heads of bright yellow florets, found at altitudes of 1,200–3,000 m. in the temperate Himalayas, Khasi hills, western ghats, and Nilgiri and Palni hills.

The plant is used as a pot-herb. In Indo-China, the bitter leaves are used as a febrifuge. The leaves, stem and flowers contain probably free triterpenes or steroids; they also show positive tests for alkaloids (Hedrick, 435; Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41,** 853; Simes *et al., Bull. sci. industr. Res. Org. Aust.*, No. 281, 1959, 14; Webb, ibid., No. 268, 1952, 35).

PICRORHIZA Royle ex Benth. (*Scrophulariaceae*)

A small genus of perennial herbs distributed in the alpine Himalayas and extending to the mountains of Yunnan in China. Two species occur in India.

P. kurroa Royle ex Benth.

D.E.P., VI(1), 228; Fl. Br. Ind., IV, 290 in part; Coventry, Ser. II, Pl. XLV.

SANS.—*Katuka, katurohini*; HINDI & BENG.—*Kuru, kutki*; MAR.—*Kutaki*; GUJ.—*Kadu*; TEL., TAM. & MAL.—*Katukarogani, kadugurohini.*

KASHMIR—*Kour*; PUNJAB—*Karru.*

A low, more or less hairy perennial herb with an elongate, stout, creeping rootstock found in the alpine Himalayas from Kashmir to Sikkim at altitudes of 2,700–4,500 m. Leaves almost radical, spathulate, sharply serrate; flowers white or pale blue-purple, in a dense terminal spicate raceme; fruit an ovoid capsule.

P. kurroa furnishes the drug, Picrorhiza, obtained as dried rhizomes and roots; it is used either as an adulterant of or as a substitute for Indian Gentian (*Gentiana kurroo*). The common trade and vernacular name *Kutki* is applied to both. A fairly large quantity of the drug is collected from various places in the north-west and Sikkim Himalayas and exported regularly to the plains. The plant may be cultivated at higher altitudes in the Himalayas; it is propagated by seeds and rhizomes (Chopra, 1958, 182).

The drug consists of cylindrical, deep greyish brown pieces, usually 3–6 cm. long and 0.5–1.0 cm. in diameter, longitudinally wrinkled with annulations at the tip. It is considered to be a valuable bitter tonic, almost as efficacious as gentian. It is antiperiodic, cholagogue, stomachic, laxative in small doses and cathartic in large doses: it is reputed to have beneficial action in dropsy. Alcoholic extracts of the roots are active against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (I.P., 479; Kirt. & Basu, III, 1826; Chopra, 1958, 182; Nadkarni, I, 954; Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 108; George *et al., J. sci. industr. Res.*, 1947, **6B,** 42).

The roots of the plant were earlier reported to contain large proportion of bitter principles, mainly a glucoside named picrorhizin. According to recent work, the following substances are found in the roots:

FIG. 22—PICRORHIZA KURROA

a glucosidal bitter principle named kutkin (β-1-vanilloyl-6-cinnamyl-D-glucose, $C_{23}H_{24}O_{10}.2H_2O$, m.p. 211°, yield 3.4%), a non-bitter product (0.5%) named kurrin and later identified as D-mannitol, vanillic acid (0.1%), an alcohol kutkiol ($C_{10}H_{22}O$, m.p. 118° yield 0.06%), and a sterol kutki-sterol ($C_{24}H_{40}O$, m.p. 124°, yield 0.18%). A sesquiterpene is reported to be the odorous principle of the roots. Kutkin is bitter in a dilution of 1:7,500 (Chopra & Ghosh, *Indian J. med. Res.*, 1934-35, **22,** 263; Rastogi *et al., J. sci. industr. Res.*, 1949, **8B,** 173; Rastogi & Dhar, ibid., 1959, **18B,** 219; Rastogi, ibid., 1959, **18B,** 522; *Chem. Abstr.*, 1955, **49,** 6977).

P. scrophulariaeflora Pennell syn. *P. kurroa* Hook. f. (Fl. Br. Ind.) in part non Royle ex Benth., a herb found in eastern Himalayas in Nepal and Sikkim, has recently been raised to the status of a species. It possesses properties similar to those of *P. kurroa.*

PIERIS D. Don (*Ericaceae*)

Fl. Br. Ind., III, 460 in part.

A genus of evergreen shrubs or small trees distributed from the Himalayas to East Asia and in North America. One species is found in India.

P. formosa D. Don (NEPAL—*Balu, sheaboge*) is a handsome shrub or a small tree with elliptic-lanceolate leaves and panicles of white flowers found almost throughout the Himalayas at altitudes of 1,800-3,000 m. and in hills of Assam. The plant is reported to be poisonous; it contains andromedotoxin (Cowan & Cowan, 82; Wehmer, II, 910).

Pieris spp. — *see* **Lyonia**

Pigeon Pea — *see* **Cajanus**

Pigeons — *see* **Birds**

PIGMENT MINERALS

D.E.P., IV, 520; VI(1), 231.

Pigment minerals possess desirable colour and other physical properties and find use as such or after treatment as pigments, extenders or fillers in paint, cement, rubber products, plastics and paper. The properties and uses of pigment minerals of commerce, classified according to the colour they afford, are summarized in Table 1. Only the natural iron oxide pigments, which are of considerable commercial importance, are described here; others are described elsewhere under appropriate subject entries.

The iron oxide group of pigments are chiefly derived from three iron ores, viz. hematite, limonite and goethite. The important natural pigments are Ochres, Siennas, Umbers and Red oxides. Depending upon the state and content of iron oxide, these minerals give different tints, chiefly red, brown and yellow. They vary from earth colours of low colour intensity and low iron oxide content (e.g., coloured clays, boles, shales and slates) to almost pure iron oxide, with high tinting strength (e.g., red oxides). Ochres, siennas and umbers occupy an intermediate position.

Some of the finest ochres come from India, South Africa, Italy, France and the U.S.A. True sienna is found only in Italy and true umber in Cyprus. Best red oxide is available in the Ormuz Island in the Persian Gulf; it is also produced in Spain, Canada, U.S.A. and India. Important deposits of micaceous hematite are found in Great Britain and Austria, and those of green earth in Bohemia and Italy (Ladoo & Myers, 341; Siegel in Gillson *et al.*, 585; *Canad. Miner. Yearb.*, 1962, 367; Tarr, 510; Johnstone & Johnstone, 432; Coggin Brown & Dey, 443-47).

Ochres consist of intimate mixtures of clayey or siliceous material with 15 to 80 per cent iron oxide (limonite, goethite or hematite) commonly yielding red, yellow and brownish shades. Red ochres (HINDI—*Geru, hirmji*) contain about 15-65 per cent hematite (anhydrous iron oxide) as the colouring principle, disseminated in a siliceous or clayey base. Yellow ochres (HINDI—*Ramraj, haldimati*) contain about 15-30 per cent limonite (hydrous iron oxide) as the colouring principle, mixed with varying quantities of clay or fine sand; they vary in colour from lemon yellow to golden yellow. Ochres may grade into siennas with increasing ferric oxide content, and siennas may grade into umbers with increasing manganese dioxide content.

Ochres are formed by residual concentration. Replacement or precipitation deposits are the principal sources of ochreous minerals. They occur mostly in the regions of deep and thorough weathering; important deposits are found usually in the fractured and faulted zones of the rocks of all ages. Though occurring widely, ochres are found usually in small pockets and not as big deposits.

Siennas consist of yellow to brown mixtures of hydrous iron oxide (partly in the form of hydrated iron silicate) and clay in varying proportions, with or without siliceous matter; they may contain up to 60-80 per cent ferric oxide and a little manganese dioxide.

TABLE 1—CHARACTERISTICS AND USES OF PIGMENT MINERALS*

Minerals	Characteristics	Uses†
REDS		
Bole, ruddle or reddle Ferruginous, nonplastic clay (Fe_2O_3, 5–15%)	Red, brown to yellowish; poor tinting strength	Used locally in India in colour washes, also for dyeing cloth
Red ochre Contains anhydrous iron oxide disseminated in siliceous or clayey base (Fe_2O_3, 15–65%)	Good spreading, hiding and staining power	Used in colour washes, oil paints, coloured paper, linoleum, etc.; in protective paints for iron and steel
Red oxide Hematitic iron oxide (Fe_2O_3, 58–98%); includes Indian red, Persian Gulf red and Spanish red	Good spreading, hiding and staining power; characterized by permanence in colour	Used in exterior, anti-corrosive paints for iron and steel structures
Shales & Slates (ferruginous) Shales are consolidated clays or muds while slate is a metamorphosed shale (*see* **Building Stones**)	Low in staining power and oil absorption	Used as red pigment in linoleum and oil cloth, mortar colours and in cheap paints for priming coats, etc.
YELLOW		
Yellow ochre A mixture of clay, siliceous matter and hydrated iron oxide (Fe_2O_3, 15–30% or more)	Lemon yellow to golden yellow; good spreading, hiding and staining power	Same uses as of red ochre
BROWNS		
Sienna A mixture of clay and hydrous iron oxide in varying proportions, with a little manganese dioxide (Fe_2O_3, 60–80%)	Pure brown to reddish brown, transparent in oil vehicle; burnt sienna possesses beautiful tinting quality	Used for glazes and graining, also for making permanent tints in printing ink
Umber A mixture of clay, hydrous iron oxide, manganese dioxide and some organic matter (Fe_2O_3, 50%; MnO_2, 7–14%)	A darker shade of brown than sienna; burnt umber has deeper and richer shades than raw mineral	Used chiefly as stains, and also for tinting colours
BLUES		
Azurite [$2CuCO_3.Cu(OH)_2$] (*see* **Copper Ores**)	Azure blue, turns to malachite with the passage of time	Used in artists' colour and mountain blue
Lapis lazuli $(Na,Ca)_4.Al_2Al(NaSO_4.NaS_3.Cl)(SiO_4)_3$	Azure blue shade of beautiful tone	Used as artists' colour; now replaced by synthetic equivalent ultramarine
GREENS		
Green earth (Terre verte) A mixture of ferrous silicate and silicates of alkalies and magnesium, composition variable	Durable but often deficient in opacity and dull in colour intensity	Used as a base for cheap lake
Malachite (Mineral green) [$CuCO_3.Cu(OH)_2$] (*see* **Copper Ores**)	Bright green shade	Used in artists' colour
BLACKS		
Coal (anthracitic) (*see* **Coal**)	Low in staining power, tinting strength and oil absorption	Used as filler and extender
Graphite (*see* **Graphite**)	Dark grey to shining black; good opacity and spreading power, oil absorption and tinting strength low	Used in anti-corrosive paints and electrically conducting paint films, also for colouring rubber, cement and flooring tiles
Ilmenite ($FeO.TiO_2$) (*see* **Titanium Minerals**)	Good opacity, mixes readily with oil vehicles, anti-corrosive	Used for the preparation of anti-corrosive fillers and undercoatings; source of Titanium dioxide—a white pigment
Magnetite (Fe_3O_4) (*see* **Iron Ores**) A magnetic oxide of iron	Greyish black, anti-corrosive	Used mostly as metal primer
Micaceous hematite A crystalline variety; flaky structure	Deep black, lustrous; anti-corrosive.	Used in anti-corrosive paints

Contd

TABLE 1 - *Contd*

*Minerals	Characteristics	Uses†
Pyrolusite (MnO_2) and Hausmannite ($MnO.Mn_2O_3$) (*see* **Manganese Ores**)	Deep black to brown; withstands high temperature	Used as drier in the preparation of boiled linseed oil; sometimes as pigment where high temperature is involved
Shales & Slates (carbonaceous) Clays containing carbonaceous matter (*see* **Building Stones**)	Low in colour, tinting strength and oil absorption	Used as black-filler for iron work, also as paint for buildings
WHITES		
Asbestos (*see* **Asbestos**) Includes chrysotile ($3MgO.2SiO_2.2H_2O$), anthophyllite [$(Mg.Fe)O.SiO_2$] and other minerals; fibrous in nature	Characterized by infusibility, high heat and electrical resistance and insolubility in acids	Used as binding material in fireproof and other paints, also as filler
Barite ($BaSO_4$) Crystalline barium sulphate (*see* **Barium Minerals**)	Practically transparent in oil vehicles, little hiding/reducing power, chemically inert	Used in undercoats and primers, also as filler and as base for lithopone
Chalk & Limestone ($CaCO_3$) (*see* **Limestone**)	Grinds to a white powder (Whiting)	Used as extender in oil paints; in distempers and ceiling white
China clay (Kaolin) ($Al_2O_3.2SiO_2.2H_2O$) (*see* **Clays**)	High water absorbing properties; induces thixotropy and enhances hiding power in water-thinned and emulsion paints	Used in interior flats and semi-glosses, primers and undercoats; also as a base for lakes and as reinforcing agent and filler
Gypsum ($CaSO_4.2H_2O$) (*see* **Gypsum**)	Practically transparent in oil, slightly soluble in water	Used in limited quantity in paints and water thinned distempers
Magnesite ($MgCO_3$) (*see* **Magnesite**)	.. ..	Used in paints required to dry with a dead flat finish; also as filler
Muscovite [$H_2KAl_3(SiO_4)_3$] (*see* **Mica**)	Chemically inert, improves settling quality, crack resistance and durability	Used in emulsion paints
Ground quartz (SiO_2) (*see* **Quartz & Silica**)	Chemically inert, improves brushability and provides "tooth" to undercoats	Used as inert extender in paints and as filler in wood work, rubber, insecticides, etc.; also in rough texture finishes
Talc ($2MgO.4SiO_2.H_2O$) (*see* **Steatite & Talc**)	Chemically inert, good settling characteristics and durability, retards cracking in paint films	Used in gloss-paints and exterior house paints, also as filler in cosmetics, rubber, plastics, linoleum, etc.

* Ladoo & Myers, 341-50; Wlth India—Industrial Products, pt VI, 137; Heaton, 91, 109, 122, 141, 148, 163; Chatfield, 1955, 229, 276; Johnstone & Johnstone, 432 44; Remington & Francis, 58, 67, 131, 141.

† Cross references within the brackets refer to entries in Wlth India—Raw Materials, where more details are given regarding the minerals.

Umbers consist of mixtures of clay, hydrous iron oxide (Fe_2O_3, *c.* 50%), manganese dioxide (MnO_2, *c.* 7–14%), organic matter and sometimes siliceous matter. Umbers have a darker shade of brown than siennas.

Burnt siennas and umbers, made by calcining raw minerals, have deeper and richer shades.

Red oxide is the term applied to various types of pigment-grade hematitic minerals, generally with 58–98 per cent ferric oxide.

Micaceous hematite, so named on account of its platy character, is a black oxide of iron having metallic lustre.

Bole is a ferruginous (Fe_2O_3, 5–15%), nonplastic, red or brown to yellowish clay.

Shales and Slates—Shales are consolidated clays or muds, while slate is a metamorphosed shale. They are coloured red due to the ferric oxide, and black due to carbonaceous matter.

Green earth (*Terre verte*) consists principally of ferrous silicate mixed with silicates of the alkalies and magnesium (Ladoo & Myers, 344–46; Bateman, 225, 727; Sriramachandramurty & Reddy, *Ind-Com J.*, 1954, **9**, 197; Siegel in Gillson *et al.*, 587; Johnstone & Johnstone, 437–38, 441; Remington & Francis, 131).

DISTRIBUTION

Andhra Pradesh—In Kurnool district, yellow ochre has been mined near Betamcherla (15°27': 78°09') and Ramallakota (15°34': 78°01'). Good quality material has been reported from Ambapuram (15°27': 78°08'), Uyyalavada (15°38': 78°05'), and Krishtriapuram (15°35': 78°02'). It also occurs near Pangidi (15°43': 78°41') and Pasurutla (15°47': 78°41'). In East Godavari, considerable quantities of good red ochre are found near Dudukuru (17°02': 81°36') and Kateru (17°02': 81°47'); in West Godavari, soft limonitic material is available at Dawarka-Tirumala (16°57': 81°15'). Both the deposits are suitable for use in colour washes and cheap paints. In Cuddapah district fairly large reserves of ochre are found near Chabali (14°30': 78°36') and Mittamidapalle (14°25': 78°44'). Pockets of yellow ochre have been reported near Nandimandalam (14°24': 78°31'). Uppalapalle (14°33': 78°47'). Sidhout (14°26': 78°55') and Bhakarapeta (14°25': 78°57'). In Chittoor district, yellow ochre occurs near Tilavaram (13°23': 79°40'), and in Vishakhapatnam, red ochre is reported from Araku (18°20': 82°51') and other localities.

Red oxide is quarried near Mantapampalli (14°19': 79°05') and Erraguntlakota (13°57': 79°16') in Cuddapah district, and at Gutupalle (15°25': 78°02') in Kurnool. Hematitic material suitable for use as pigment is available at Veldurti (15°33': 77°56') in Kurnool and near Basireddipalle (15°47': 79°35') in Nellore.

Some of the ferruginous clay bands found in Kamthi beds in Adilabad are ochreous and may be used for making paints. Pale pink ochreous shales used as colour wash occur in the hill ranges near Doranala (15°54': 79°06') in Kurnool district (Chatterjee, 395–96; *Indian Miner. Yearb.*, 1964, 692).

Bihar—Ochre is worked in Shahabad district at Mandpa (24°44': 83°40') and Chuthan (24°38': 83°44'). In Singhbhum district, red ochre is found in Kolhan area, Jhairdih (22°47': 85°31'), Chandil (22°57': 86°04'), Goilkera (22°31': 85°23') and also near Mangru (22°29': 86°16'), Maheshpur (22°22': 86°30'), Labari (22°36': 86°43'), and Kuria (22°32': 85°31'); and yellow ochre at several places in Kharsawan (22°48': 85°53') and near Goilkera. Red ochre has also been recorded near Garea (24°08': 85°54') in Hazaribagh, and Kolkant (24°26': 87°26') in Santal Parganas.

Brown earths have been reported to occur at Leda Buru (22°28': 85°22') and Basadera (22°40': 86°30') in Ranchi.

Considerable deposits of micaceous hematite occur at Bicha Buru (22°39': 85°24'), Karamta Buru (22°40': 85°25') and Lukud Buru (22°40': 85°27') in the Porahat region, Singhbhum. They are a potential source of black pigment.

A reddle of varying colours was quarried near Gaya and used for dyeing clothes. Clays used as colour wash occur at Metiabandi (22°33': 86°38'), Khari Dungri (22°32': 86°45'), and Dharadih (22°43': 86°32'), and are also recorded at Asura (22°44': 85°52') in Singhbhum. Red and yellow lithomargic clays have been observed in Lohardaga (23°26': 84°40') and Chuhimati (23°25': 84°24') areas of Ranchi district (Chatterjee, 396–97).

Gujarat—Yellow ochre has been recovered near Sajanpur (22°40': 70°54') and Wankaner (22°37': 70°59') in Madhya Saurashtra and near Bharware (21°45': 69°30') in Porbandar. Ochre is also worked near Lakhpat (23°50': 68°50') in Kutch, and Padvania (21°41': 73°18') in Broach. About 3 million tonnes of red ochre reserves are reported to occur near Rajpur (23°01': 71°25') in Surendranagar (Zalawad) district, where the mineral also occurs at Ankevalia Mota, Baisahebgarh, Chorvirda, and Khod. About 50,000 tonnes of yellow ochre are estimated to be recoverable from a yellow sandstone near Gangiawadar (22°38': 71°05'). In Gohilwad, extensive deposits of yellow ochre are located west of Lakhanka (21°31': 72°17'). Occurrence of sandy red and yellow ochres has been noticed at several places in the Garia hills in western Kutch. Bright yellow ochre of excellent quality has been found in a well shaft near Palakra (21°45': 69°25') in Porbandar.

Ochres, coloured clays and variegated earth occur abundantly around Nandana, Ran, Mewasa, Virpur and other localities in Halar. Large quantity of red bole is seen below the trap on Bed-Sika road about 14 km. from Jamnagar; it has also been recorded at Verawal. In Sorath, clays of variegated colours associated with laterite are worked in the vicinity of Barula (21°02': 70°24') and Bhetali (20°57': 70°35') for local colour wash (Chatterjee, 397–98; *Indian Miner. Yearb.*, 1964, 693; Roy, 1953, 179).

Himachal Pradesh—Large quantities of yellow ochre are reported to exist near Dauksa (32°13': 78°05') in Spiti (Chatterjee, 404).

Jammu & Kashmir—Ochre has been worked locally from the decomposed Panjal Traps forming Poshkar (34°02': 74°30') ridge, in Baramula district. About 200,000 tonnes of reserves of red and yellow ochres are reported from Uri area at Rata Sar

(34°10′:73°59′), Nur Khawah (34°09′:74°07′), and Jhuggi (34°09′:73°57′). A deposit has been recently found near Braripure (Chatterjee, 399; Badyal, *East. Met. Rev.*, 1955–56, **8**, 630; *Indian Miner. Yearb.*, 1964, 693).

Madhya Pradesh—Red ochre has been worked at Gandai (21°40′:81°10′) and Thakurtala (21°39′: 81°02′) areas in Durg; and semi-ochreous hematite at Jauli (23°23′:80°17′) in Jabalpur. Important deposits of red and yellow ochres are found in Gwalior and Satna districts. About 89,000 tonnes of red ochre are estimated to occur in Behat, Rangwan, Sumowli and Dhiroli in Gwalior. In Satna district, about 143,200 tonnes of red ochre and 262,600 tonnes of yellow ochre are estimated to occur in several localities, particularly at Amirthi (24°53′:80°57′), Partapur (24°24′:81°05′), Madhogarh (24°30′:80°59′), Lidra, and Khogaha hills; red ochre is also reported from Lakhanpur (24°57′:80°57′). Occurrence of red ochre has been reported from Nardha (26°13′:78°48′), Gumanpura (26°14′:78°47′), and Baro Babuganj (26°10′:78°39′) in Datia, and near Palakhal (22°23′:76°20′) in Dewas. In Durg, it is found at Khara (21°50′:80°51′), Dongaria (21°50′: 80°52′), and Mahera Dhabri (21°20′:80°44′), and in Gird at Santao (26°02′:78°11′), Par (26°02′:78°05′) and Behat (26°10′:78°33′). Red ochre occurs at Kukuria (23°16′:83°37′), Nopani Pahar (23°08′: 83°34′), and Giabura (23°02′:83°34′) in Raigarh; Laba (22°47′:83°13′) in Surguja; and Lachhmanpur, Khandarbeh, Koila, Ghatakheri and Tulsikhol in Rajgarh. Yellow ochre has been reported from Palakhal in Dewas; Garra (21°55′:80°55′) in Durg; Bandholi (26°12′:78°20′) in Gird; Baherna (23°19′: 83°58′) in Raigarh; Semaria (24°52′:81°13′) in Rewa; Tekra-Manwa-ka-Bhand near Bhopal; and Bharouli (23°55′:80°55′) in Shahdol. Ochre has been recorded near Naika Pahar (22°02′:75°09′), Bawangaza (21°59′:74°51′), Shindikhodra (21°56′:74°53′), Niwali (21°41′:74°55′), and Purusheda (21°41′:74°59′) in Nimar.

Quarries at some places in the districts of Jabalpur, Durg, and Hoshangabad have been reported to yield red oxide.

Some ochreous clays from Panna are used as pigments, and soft earthy laterite from Shivpuri as local red wash. Similar material occurs near Maharwani (25°27′:77°08′) in Morena; and yellow shale near Piparia in Durg.

Green earth is found in association with Deccan Trap; good quality material is located at Pipri Buzurg (21°57′:75°12′), Nukbera Pahar (22°03′: 75°11′), Gaibera Pahar (22°02′:75°05′) and Kansel (21°58′:75°04′) in Nimar district. The bed at Nukbera Pahar is about 3 metres thick (Chatterjee, 399; *Indian Miner. Yearb.*, 1964, 693; Coggin Brown & Dey, 444).

Madras—Yellow ochre has been worked at Trivandipuram (11°45′:79°46′) in South Arcot. Yellow and red ochres occur near Anavari (10°13′: 78°50′), and yellow shales usable as ochre near Sivaganga (09°51′:78°29′), and Panamangudi (09°56′: 78°37′) in Ramanathapuram. Red and yellow shales used as colour wash are reported from Sengirai Reserve Forest (10°15′:78°50′) and also near Tiruvarangulam (10°21′:78°53′) in Tiruchchirappalli.

Red ochreous earth has been located near Tachchur (12°34′:79°17′) and Madimangalam (12°36′:79°11′) in North Arcot, near the church at Ootacamund, and Kanniyakudi (11°11′:79°41′) in Thanjavur. Some highly coloured clays of Cretaceous age, exposed between Terani (11°06′:78°56′) and Karai (11°08′: 78°56′) in Tiruchchirappalli, could be used as pigments (Chatterjee, 400–01).

Maharashtra—Yellow ochre has been worked near Khairi (21°09′:78°49′), and Kalmeshwar (21°14′: 78°59′) in Nagpur district for local use. The red boles associated with the Deccan Trap have been used in the manufacture of red paint (Chatterjee, 401: Coggin Brown & Dey, 446).

Mysore—Several deposits of red and yellow ochres are found at Vadarhalli (15°14′:76°28′), Kammadheruvu (15°01′:76°37′), Sundaram Beneha (15°01′: 76°32′), Obalagandi (15°04′:76°31′), and Kanevehalli (15°03′:76°30′) in the district of Bellary; Chiknaikanhalli and Gubbi taluks in Tumkur; Holalkere and Hosdurga taluks in Chitradrug; and in parts of Kolar, Mulbagal and Srinivasapur taluks in Kolar district. Occurrences of ochre have been reported at various localities in the districts of Belgaum, Bidar, Bijapur, Dharwar, Gulbarga, and North and South Kanara.

Large deposits (227,100 tonnes) of red oxide occur at Bellary-Hospet, Bellary and Ubbalegundi mines, and also near Haragonadona (15°08′:76°47′). Bellary is the important centre of red oxide mining.

Rich red and yellow ochreous argillite pigments have been worked at the Adargani mine near Kumaraswami temple (15°01′:76°34′) in Bellary. Red bole beds are found at many places in Bijapur on the Deccan Trap. Lithomarge of varying shades, suitable for colouring purposes, is found in the Sorab and Sagar taluks in Shimoga. Coloured clays used locally

occur at many places in Chitradrug and Tumkur districts.

Occurrence of green ochre is reported near Golhalli in Tumkur district and a few other places (*Indian Miner. Yearb.*, 1964, 695; Rama Rao, B., 100–01; Chatterjee, 401–02).

Orissa—Large deposits of red ochre of good quality occur on the lateritic hills near Sarayi (18°19′:82°45′) and Geruputtu (18°35′:82°44′) in Koraput district, where yellow shale exposed near Binusuli (19°02′: 82°18′) yields material used locally. Yellow and brown ochres suitable as pigment are found near Kodakora (21°47′:85°14′) in Keonjhar. Occurrences of ochre have been reported at various localities in the districts of Cuttack, Dhenkanal, Ganjam, Mayurbhanj, Sambalpur and Sundargarh.

Red oxide has been recorded near Jarapa (19°40′: 83°25′) in Koraput district.

Ochreous lithomarge occurs at Gobindprasad; red clay near Khandpara and Madhubana in Puri; and reddish laterites at Bhanjibasa in Mayurbhanj; they are used locally. Occurrences of red clay have also been recorded near Palsabani (21°00′:84°52′) and Similipal (21°04′:84°47′) in Dhenkanal. Red shales found near Gerujor (20°31′:82°36′), Khadupani (20°13′:82°32′), Jobbhata (20°10′:82°31′), and other localities in Kalahandi yield a soft ochreous material which improves in quality on grinding and washing (Chatterjee, 402–03).

Rajasthan—Red ochre of good quality occurring at Kanauj in the Nimbahera (24°38′:74°41′) region in Chitorgarh has been quarried for a long time; a large deposit of ochre has been recorded near Chitorgarh railway station. Ochres have been reported from various localities such as Jhaz (26°58′:77°08′), Hathori (27°00′:77°07′), Nagla Gothia (26°37′:77°09′), and Sunchra (27°38′:77°20′) in Bharatpur, and also from Bundi and Dungarpur districts.

A black slate occurring near Kishangarh (26°34′: 74°53′) in Ajmer has been used as pigment. A light bluish grey shale overlying the lignite at Palana (27°51′:73°17′) in Bikaner may also find a similar use. Appreciable quantity of yellow ochreous clay has been recorded near Devikot (27°42′:71°12′) in Jaisalmer (Chatterjee, 404).

Uttar Pradesh—Yellow ochre occurs near Baital Ghat (29°33′:79°21′) and is locally used as a pigment. Red ochre is found at Lakhanpur (24°58′:80°57′) in Banda (Chatterjee, 404).

West Bengal—Production of ochre is recorded from the districts of Bankura and Midnapur. In Burdwan, the best type of ochre is reported to occur at Ranimahal.

Clay suitable for colour wash occurs at Rajabasa (22°49′:86°24′) in Purulia (*Indian Miner. Yearb.*, 1964, 695; Chatterjee, 404).

Mining and Preparation

The mining of ochres and oxides in India is generally done by open cast method, though pillar and stall method and its variations are also used in some mines. The minerals are won mostly by simple manual means. A few producers use drilling equipment. Mining cost is low because the earth pigments, except red oxide, are soft minerals. There were 40 ochre mines in operation in India towards the end of December, 1967 [*Indian Miner. Yearb.*, 1964, 694; Sriramachandramurty & Reddy, loc. cit.; *Mon. Bull. Miner. Statist. & Inform.*, 1967, 7(11 & 12), I: 15].

Ochres and oxides are prepared for the market by comparatively simple processes of crushing, grinding, washing, levigation and calcination. Any one or all of these operations may be applied to a single pigment. The mined material is weathered in the open and the non-colouring impurities exposed are removed by manual sorting. The material is then crushed, ground, and refined by levigation. The levigated pulp is drained in bags or filter pressed, dried and again powdered if necessary. Various desirable colour tones may be obtained through carefully controlled and regulated process of calcination. However, in general, no elaborate method of processing is adopted by the mine owners in India. Pigment minerals are sold in lump as well as in powder form of desired mesh to the paint industry (Sriramachandramurty & Reddy, loc. cit.; Ladoo & Myers, 341; *Indian Miner. Yearb.*, 1962, 458).

Properties and Uses

Ochres and oxides are characterized by their permanence in colour, opacity to ultra-violet light, and excellent covering power. They are non-bleeding, produce hard and impervious paint films which resist weathering, give good protection to wooden or metal structures, and can be used in either oil or water media. Their wide geographic distribution, low cost of production, and chemical stability, add to their general usefulness and importance in the paint industry (Johnstone & Johnstone, 432; Ladoo & Myers, 341).

Ochres have a wide range of characteristics (Fe_2O_3, 14.3–72.3%; insoluble matter, 12.3–67.6%; moisture, 0.6–3.7%; and oil absorption, 25–35%). They are fast to light in self-colour and tint and also to lime. They are generally inert and may decompose under some conditions by certain acids (Remington & Francis, 134–35; Chatfield, 1955, 235).

Red oxides exhibit a considerable range of colour and are amongst the most stable and inert pigments. They do not react with other pigments, and are fast to light in self-colour and tint, and also to alkali. The colour and fineness of natural red oxides are more important than their tinting strength (Chatfield, 1955, 231–32).

Uses—Ochres are principally used as a pigment or stain in paint manufacture, and also in colour washes, distempers, paper and linoleum making. They find extensive use in protective paints for iron and steel structures. Ochres are also employed for colouring certain roofing and flooring tiles, concrete slabs, and sand lime bricks. They are utilized as tinting, filling or reinforcing agents in phenol-formaldehyde plastics, and as a filler in wrapping paper and cardboards. In rubber industry, they are used in tyre and rubber-flooring compositions.

Yellow ochre may be calcined to burnt ochre, whereby it is converted to anhydrous red ferric oxide. Burnt ochre, used as artists' colour, is quite permanent (*Indian Miner. Yearb.*, 1963, 597; Sriramachandramurty & Reddy, loc. cit.; Johnstone & Johnstone, 442; Heaton, 110; Remington & Francis, 203).

Red oxides are principally used in protective paints for structural steel, as a durable inert absorber of destructive light-rays. With certain exceptions, they have no corrosion inhibition value. Red oxides are probably consumed in larger tonnage than any other single pigment. Persian Gulf red oxide (Fe_2O_3, *c.* 72%; av. particle size, 0.84 μ; oil absorption, 22–23%) is considered to be the best red oxide. It is valued for its bright red colour and produces very attractive warm blue tint.

Umber and sienna are used in various mixed paints, because of their beautiful tinting quality; they are chiefly employed as stains (Chatfield, 1955, 231; Heaton, 113; Remington & Francis, 135).

Production and Trade

Statewise annual production of ochres and oxides is given in Table 2. Madhya Pradesh is the largest producer. Andhra Pradesh, Mysore, and recently

TABLE 2—STATEWISE PRODUCTION OF OCHRES AND OXIDES*

(Qty in tonnes)

	1963	1964	1965	1966	1967
Madhya Pradesh	16,155	19,987	19,149	17,518	12,204
Mysore	7,058	6,659	6,808	6,146	9,384
Andhra Pradesh	4,743	5,279	8,934	3,884	5,023
Maharashtra	..	..	395	1,226	739
West Bengal	255	551	760	821	176
Rajasthan	154	165	306	2,158	7,879
Gujarat	..	300	235	280	637
Total	28,365	32,941	36,587	32,033	36,042

* *Indian Miner. Yearb.*, 1964, 695–96; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11&12), 1:27; 1967, **7**(11&12), 1:26.

TABLE 3—CLASSIFIED PRODUCTION OF OCHRES AND OXIDES*

(Qty in tonnes)

	1961	1962	1963	1964
Yellow ochre	8,769	11,172	13,319	16,451
Red ochre	4,341	5,289	4,814	4,765
Red oxide	3,840	4,860	6,590	10,215
Unspecified	1,854	1,482	3,642	1,510

* *Indian Miner. Yearb.*, 1962, 460; 1963, 596; 1964, 697.

TABLE 4—INDIAN STANDARD SPECIFICATIONS FOR OCHRES AND OXIDES

	Ochre (red & yellow)[1,a]	Sienna (raw & burnt)[2,b]	Umber (raw & burnt)[3,c]	Red oxide[4,d]
Vol. matter, % (max.)	1.0	3.0	3.0	0.5
Residue on 240 mesh B.S., Sieve, % (max.)	0.5	0.5	0.5	0.5
Matter sol. in water, % (max.)	1.0	2.0	1.5	2.0
Acidity, % (max.)	0.1	0.1	0.1	
Alkalinity, % (max.)	0.1	0.1	0.1	0.1

[1] IS:47 1950; [2] IS:48–1950; [3] IS:49–1950; [4] IS:46–1950.
[a] Fe_2O_3 ≮ 35%, calcium compounds (as CaO) ≯ 5%, shall be free from organic matter; [b] shall be free from added colouring matter; [c] shall be free from organic matter; [d] Fe_2O_3 ≮ 70%.
Note: Oil absorption, within 5% of approved sample; colour as specified; staining power and tone, as per approved sample.

TABLE 5—EXPORTS OF OCHRES AND OXIDES FROM INDIA*

(Qty in tonnes and Val. in thousand Rs.)

	1963		1964		1965		1966		1967	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Red oxide (Persian Gulf type)	515	95	593	61	401	73	152	31	176	31
Ochre (yellow)	39	7	395	67	..	..			..	
Umber & Sienna	16	3	21	4	..	..			..	
Earth colours					290	56	1,274	348	243	

* *Indian Miner. Yearb.*, 1964, 133–35; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11&12), 1:43; 1967, **7**(11&12), 1:44.

TABLE 6—IMPORTS OF OCHRES AND OXIDES INTO INDIA*

(Qty in tonnes and Val. in thousand Rs.)

	1963		1964		1965		1966		1967	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Red oxide (Persian Gulf type)	1,576	966	1,683	948	2,033	978	1,542	724	2,304	2,168
Umber & Sienna	4	2	12	6	..	..	..	..	..	..
Earth colours	..	..	..	..	60	61	58	37	133	160

* *Indian Miner. Yearb.*, 1963, 138; 1964, 159; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11&12), 1:47; 1967, **7**(11&12), 1:48.

Rajasthan are the other important producing States. Yellow ochre is produced in the largest quantity. The classified production of ochres and oxides in the country is given in Table 3.

Grades and Specifications—For marketing, ochres are graded according to quality. Certain physical tests are usually carried out to determine their colour, particle size, staining power, hiding power (opacity), oil absorptive power, etc. Strong staining power, brightness of tint and fineness of texture are the factors determining grade and price of the material. Ochres mined in the country are generally of high quality and fall under two broad groups: (*i*) the transparent ochre of high ferric oxide content and good staining power, and (*ii*) pale yellow to golden ochre of low specific gravity, and medium to high iron oxide content and staining power. The indigenous material, however, lacks the toning capacity of the imported Persian Gulf red oxide. This problem needs to be investigated with a view to developing a process for upgrading the toning capacity of Indian ochres (Roy, *Mem. geol. Surv. India*, 1959, **86**, 253; Remington & Francis, 132; *Indian Miner. Yearb.*, 1964, 698, 701).

Indian Standard specifications for ochres, sienna, umber, and red oxide are given in Table 4.

Exports and Imports—Most of the ochre produced is consumed indigenously. Comparatively small quantities of ochre, mainly yellow ochre, are exported to the neighbouring countries (Table 5).

Table 6 gives the imports of red oxide, umber and sienna. Red oxide (Persian Gulf type) is imported in the country for toning purposes. The U.K., Iran and West Germany are the main suppliers of this material to India (*Indian Miner. Yearb.*, 1964, 698–701).

Pigmy Spermwhale — *see* **Porpoises**

Pigs, Hogs and Boars — *see* **Livestock,** Supplement to Wlth India — Raw Materials, VI

PILEA Lindl. (*Urticaceae*)

D.E.P., VI(1), 236; Fl. Br. Ind., V, 551.

A genus of annual and perennial herbs or undershrubs widely distributed in tropical and sub-tropical regions. About 20 species are found in India.

P. glaberrima Blume syn. *P. smilacifolia* Wedd. is a stout undershrub with stems up to 120 cm. long, and elliptic-lanceolate leaves found in eastern Himalayas at altitudes of 600–1,200 m. and in Sibsagar, Khasi and Mishmi hills in Assam. It is reported to yield a fibre.

P. melastomoides Blume syn. *P. trinervia* Wight is a robust succulent herb, up to 2 m. in height, and with very variable oblong-lanceolate to broadly elliptic leaves found in hills of South India. The leaves are aromatic and are used as a seasoning in Java (Burkill, II, 1726).

P. microphylla Liebm. syn. *P. muscosa* Lindl. (ARTILLERY PLANT, GUNPOWDER PLANT) is a small prostrate or sub-erect herb, c. 15 cm. high, native of tropical America, cultivated in Indian gardens and also found as a weed in many places. It has graceful foliage of tiny, spathulate or rounded, succulent leaves and is suitable as an edging for flower beds and for rockeries. It is reported to be affected by blight (*Colletotrichum capsici* Butler & Bisby). The plant can be easily propagated by cuttings. When shaken it scatters a cloud of pollen in so marked a way as to attract attention. It is reported to be useful for stomach and intestinal troubles; an infusion is used as diuretic. Crushed leaves are applied to sores and bruises [*Biol. Abstr.*, 1961, **36**, 3464; Desai, *Indian Fmg, N.S.*, 1956-57, **6**(12), 12; Burkill, II, 1726; Gopalaswamiengar, 344; Heyne, *J. sci. Res. Indonesia,* 1952, **1** (suppl.), 21; Brown, III, 182; Standley & Steyermark, *Fieldiana, Bot.*, 1952, **24**(3), 416].

P. scripta Wedd. is a herb c. 90 cm. in height, with elliptic-lanceolate leaves found almost throughout the Himalayas at altitudes of 1,150-1,800 m., Khasi hills, Manipur and in parts of Orissa and Madhya Pradesh. It is reported to yield fibre.

PILOCARPUS Vahl (*Rutaceae*)

Bailey, 1947, III, 2623.

A genus of shrubs or small trees native of tropical America, mainly Brazil. Two species, *P. jaborandi* Holmes and *P. microphyllus* Stapf, are well known as source of the drug Jaborandi. They are not found in India. Cultivation of *P. microphyllus* is recommended for trial in the tropical rain forests of Bengal (Nayar & Chopra, 40).

Jaborandi of commerce mainly consists of the dried leaflets of the two above mentioned species, although leaves of other species are also used. They are aromatic and bitter in taste and contain a volatile oil, resin and a number of alkaloids, of which the most important is pilocarpine, which occurs as a colourless oil or crystal (m.p. 34°). The use of the crude drug has, however, been replaced by its alkaloid, pilocarpine, which is present to the extent of 0.5 per cent. Pilocarpine is administered parenterally as a powerful diaphoretic, especially in renal dropsy. It is also used to procure contraction of the pupil and to reduce the intra-ocular pressure in glaucoma. The physiological action of pilocarpine is antagonistic in all respects to that of atropine; the former is, therefore, used as an antidote to belladonna and atropine poisoning. Pilocarpine is official and is used either in the form of chloride or nitrate (Allport, 81-83; Wallis, 121; Youngken, 498; U.S.D., 1955, 1060; I.P., 480).

PIMENTA Lindl. (*Myrtaceae*)

A small genus of trees distributed in West Indies and tropical America. Two species are introduced into India.

P. dioica (Linn.) Merrill syn. *P. officinalis* Lindl.
ALLSPICE TREE, JAMAICA PEPPER TREE, PIMENTO TREE

Bailey, 1949, 730; Krishna & Badhwar, *J. sci. industr. Res.*, 1950, **9A**(3), suppl., 234, Fig. 51.

A bushy evergreen tree, 6-9 m. high, indigenous to West Indies and tropical America and grown in gardens in India. Leaves oblong to oblong-lanceolate, leathery; flowers white, in terminal and axillary trichotomous paniculate cymes; fruit a globose berry, about the size of a pea, black or purple, two-seeded; seeds reniform, deep brown.

P. dioica is grown for its unripe fruits which, when rapidly dried, form the Allspice, Jamaica Pepper or Pimento of commerce. The plant is reported to be cultivated in gardens, especially in Bengal, Bihar and Orissa. It is said to grow well in Bangalore and fruit heavily. It has been recommended for growing in the hilly districts of Mysore along the river valleys. It is propagated by seeds. Only fresh ripe fruits must be selected for seeds. Seeds should be sown under shade in freshly prepared beds or in boxes or pots. The beds or boxes should be well watered before sowing, and the seeds should be thinly broadcast and lightly covered with coir waste or fine soil. Seedlings are potted in large containers at the 2- and 4-leaf stage, and are ready for planting out in the field when they are 25-38 cm. high. The tree begins to bear fruits when about seven years old and continues so up to twenty years. The berries are picked when mature, but still green. If the berries are fully ripened, they lose their flavour. The berries are quickly dried in the sun for 4-10 days; they become wrinkled like pepper and turn reddish brown in colour, when the aroma becomes more pronounced. A tree is reported to give an average yield of 35-45 kg. of berries. Jamaica is the chief producer of berries where they are gathered

from naturally growing plants; the bulk of the berries are exported to U.S.A. and Europe [Mari Gowda, *Lal-Baugh*, 1957, **2**(2–3), 50; Ward, 7–10, 13, 15; Guenther, IV, 370–72; Krishna & Badhwar, *J. sci. industr. Res.*, 1950, **9A**(3), suppl., 234; Hill, 447].

Dried berries of commerce are nearly globular, 4–7 mm. in diameter, with a rough surface and a reddish brown colour. They possess an aromatic taste and flavour resembling a mixture of cinnamon, cloves and nutmeg, and hence the name Allspice. The berries are used as a condiment, as a flavouring ingredient in catsups, soups, sauces, pickles, canned meats, sausages, etc. They are used in the liquor industry, especially as a favourite ingredient for mulled wines, and as a perfume in soap making (Parry, J. W., 21–22; Guenther, IV, 372; Ward, 16; Steinmetz, II, 343).

Allspice is available whole or ground. During the past 5 years, India imported about 15–50 kg. of the spice annually from Malaysia or Singapore. Allspice is used as an aromatic stimulant in digestive troubles. It was formerly used in medicine as an adjuvant to tonics and purgatives; it was considered to be carminative. It is an anodyne against rheumatism and neuralgia (Steinmetz, II, 343; U.S.D., 1955, 1063).

Allspice owes its characteristic odour to the presence of an essential oil (3.3–4.5%), concentrated mainly in the pericarp. In addition, it contains quercitannic acid (over 8%) responsible for the astringency, a soft resin with a burning taste, fixed oil (5.8%), proteins (5.8%), crude starch (20%), and traces of an alkaloid. The essential oil, known as Pimenta Berry Oil, is obtained by steam distillation of the crushed dried berries. It has a yellow to yellowish red colour, darkening with age, and possesses the characteristic odour and flavour of allspice. The characteristics of the oil are as follows: sp. gr.$^{15°}$, 1.024–1.055; $[\alpha]_D$, $-0.5°$ to $5.0°$; $n_D^{20°}$, 1.525–1.536; and sol. in 1–2 vol. or more of 70% alcohol. It contains eugenol (65–80%) as the principal constituent, together with eugenol methyl ether (9.6%), phellandrene, cineole, caryophyllene and a terpene alcohol (Guenther, IV, 372; Thorpe, IX, 647; Gildemeister & Hoffmann, VI, 72).

Pimenta berry oil is used for flavouring condiments and food products and in perfumery, soap and pharmaceutical preparations. The oil replaces the ground spice to great advantage, as it is of more uniform quality and can be dosed more easily and accurately. The oil is used as a carminative and stimulant. It shows bactericidal, fungicidal and antioxidant properties (Gildemeister & Hoffmann, VI, 72; Guenther, IV, 375; U.S.D., 1955, 1063; Claus, 1961, 232; *Chem. Abstr.*, 1956, **50**, 504, 12340).

The dried leaves on steam distillation yield 0.7–2.9 per cent of an oil (Pimenta Leaf Oil), which like berry oil contains eugenol as its main component but has an inferior odour and flavour. Pimenta leaf oil has the following physico-chemical properties: sp. gr.$^{15°}$, 1.026–1.065; $[\alpha]_D$, inactive to $-5.5°$; $n_D^{20°}$, 1.530–1.540; eugenol content, 65–96%; and sol. in 1–2 vol. of 70% alcohol. It is employed as a substitute for and adulterant of the more expensive berry oil. It is used also for the isolation of eugenol. Both the berry and leaf oils are occasionally adulterated with clove oil or certain fractions of it (Gildemeister & Hoffmann, VI, 73–74; Guenther, IV, 374).

The leaves contain tannin and may be used locally for tanning purposes. The bark contains tannin and a small quantity of an essential oil (Howes, 1953, 283; Wehmer, II, 826).

The wood (wt. 1,089 kg./cu. m.) is of dark to light salmon colour with a very firm, hard, close texture and a smooth surface. It is inclined to warp unless in very narrow widths. The wood of the saplings is mainly used for making walking sticks, umbrella handles and cart shafts (Howard, 454; Hill, 448; Record & Hess, 409).

P. racemosa (Mill.) J. W. Moore syn. *P. acris* Kostel.
BAY TREE, BAY RUM TREE

Bailey, 1949, 730.

A shrub or small tree, 6–18 m. high, indigenous to West Indies and tropical America, reported to be grown in gardens in India. Leaves obovate or elliptic, leathery, shining above, very aromatic; flowers white, in corymbs; fruit an ovoid berry, black when ripe, aromatic.

P. racemosa is grown mainly for its leaves which furnish an essential oil (Bay Oil). Bay trees are propagated from seedlings. Seeds are sown in seedbeds and seedlings transplanted in nursery beds. After 1½–2 years in the nursery, seedlings are planted out in the field. Although the tree attains a height of 18 m. or more, it is usually pruned at the top and trained to one or two main trunks with numerous side branches and maintained to a height of 3.0–3.6 m. Harvesting of leaves begins in four to five years after planting. In harvesting, either leaves are stripped from the trees, or both shoots and leaves are removed and tied in bundles for transportation to

FIG. 23—PIMENTA RACEMOSA—FRUITING BRANCH

distillery. In areas of cultivation (Dominica and Puerto Rico), yields of fresh leaves vary from 11,110 to 33,330 kg. per hectare (Guenther, IV, 381–82, 388, 385–86).

Bay oil is obtained by distillation of the green leaves, the average yield being 1.2–1.3 per cent. The oil is yellow in colour, becoming darker on exposure to air, and has a pleasant odour reminiscent of clove oil, with a sharp spicy taste. The physico-chemical properties of the oil are: sp. gr.$^{15°}$, 0.960–0.985; $[\alpha]_D$, up to $-2°$; $n_D^{20°}$, 1.506–1.520; phenol content, 57–66%; and sol. in 1–2 vol. of 70% alcohol. Eugenol is the chief constituent of the oil; other constituents identified are: methyl eugenol, chavicol, methyl chavicol, α-pinene, myrcene, *l*-phellandrene, limonene, dipentene, citral, cineole and an alcohol resembling geraniol. Bay oil finds wide use in the perfume industry, particularly in the preparation of bay rum and similar type of toilet waters. It is used to a limited extent for flavouring culinary preparations, chiefly table sauces (Gildemeister & Hoffmann, VI, 76–84; Guenther, IV, 395).

The berries yield on steam distillation 3.7 per cent of a yellowish brown essential oil, with a characteristic odour. The oil (sp. gr.$^{15°}$, 1.017; $[\alpha]_D$, $-7.05°$; sol. in 1.5 vol. of 70% alcohol) contains eugenol (73%) and *l*-phellandrene (Gildemeister & Hoffmann, VI, 85–86).

The berries are useful for culinary purposes. Powdered fruit is used in flatulence, dyspepsia and diarrhoea. The wood of the saplings is valued for walking sticks (Chittenden, III, 1573; Kirt. & Basu, II, 1056; Burkill, II, 1728).

Pimiento — *see* **Capsicum**

Pimpernel — *see* **Anagallis, Pimpinella**

PIMPINELLA Linn. (*Umbelliferae*)

A large genus of annual or perennial herbs distributed in Asia, Europe and Africa. About 30 species occur in India. One species, *P. anisum*, is widely grown for its fruits used for flavouring.

I.A.R.I., New Delhi

FIG. 24—PIMPINELLA ANISUM—FRUITING BRANCH

P. anisum Linn. ANISE, ANISEED

D.E.P., VI(1), 236 ; C.P., 887 ; Bailey, 1949, 751.

HINDI—*Saunf, sawonf, badian* ; BENG.—*Muhuri, mitha-jira* ; MAR.—*Somp, badishep* ; GUJ.—*Anisa* ; TEL.—*Kuppi, sopu* ; TAM. & KAN.—*Shombu* ; ORIYA—*Sop.*

NEPAL—*Sop.*

An annual herb, 30–60 cm. high ; leaves pinnatifid or ternately pinnate ; flowers small, white, in compound umbels ; fruit (schizocarp or cremocarp) ovoid or pyriform, laterally compressed, 3–5 mm. in length and 2–3 mm. broad, greyish green to greyish brown ; mericarp broadly ovoid, 5-ridged with short hairs and numerous vittae.

P. anisum, a native of the eastern Mediterranean region, is widely cultivated in southern and central Europe, U.S.S.R., North Africa, and to a less extent in Mexico and South America. In India, it is grown to a small extent as a culinary herb, but reports of its cultivation and production for fruits are evidently not found correct. It has often been confused with *Foeniculum vulgare* because of the common Indian name, *Saunf,* applied to both. It is stated that a commodity commonly available in Indian market under the name *Lucknow saunf* is called Indian Aniseed. Enquiries from various commercial and government sources indicate that all references to aniseed grown or produced in India refer mostly to *Foeniculum vulgare.*

The plant prefers a light, fertile or moderately rich, well-drained sandy loam. It is propagated by seeds. Seeds are sown broadcast or in drills, 20–40 cm. apart, from the middle of October to the end of November in the plains, and from the beginning of April to the end of May on hills. When the seedlings are 5–8 cm. high, they are thinned to stand 10–15 cm. apart in a row. About 13 kg. of seeds are sufficient to plant a hectare of land. The plants require frequent and thorough cultivation throughout the growing season, occasional weeding and watering once a week during dry weather. The crop is ready for harvesting in 3½ months after planting when the tips of the fruits (often called seeds) turn greyish green. The plants are either pulled out of the ground or fruiting umbels cut off, tied in bundles and then stacked in a conical pile with the fruiting heads toward the centre in cocks about 1.8 m. high. Fruits ripen in 4 or 5 days, and are then threshed out, cleaned and bagged for the market. Under favourable conditions, a yield of 445–665 kg. of fruit per hectare may be expected. Aniseeds are reported to be damaged by an insect, *Systole albipennis* Wlk. [Guenther, IV, 564–66 ; Gopalaswamiengar, 559 ; Gollan, 11 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1953, **12A**(2), suppl., 284 ; Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 23 ; Parry, J. W., 88 ; Wadhi, *Indian J. Ent.*, 1963, **25,** 382].

A large quantity of aniseed is said to be exported from India and also imported. Exports are mainly made to Afghanistan and Pakistan, while imports are mainly from Malaysia, Viet Nam and Taiwan (Formosa) (Tables 1 and 2). It appears probable that all exports refer to *Lucknow saunf* which is a fennel and the imports are evidently mostly of star anise (*Illicium verum*), particularly those received from Malaysia, Viet Nam and Taiwan. Star anise is said to

PIMPINELLA ANISUM (TRUE ANISEED)

FOENICULUM VULGARE (FENNEL)

ILLICIUM VERUM (STAR ANISE)

FIG. 25—ANISEEDS—TRADE SAMPLES

TABLE 1—EXPORTS OF ANISEED FROM INDIA

(Qty in kg. and Val. in Rs.)

	Pakistan	Trinidad	Afghanistan	Others	Total	
					Qty	Val.
1957	36,271	8,331	..	17,324	61,926	75,104
1958	13,208	3,708	..	2,032	18,948	35,507
1959	60,810	3,810	552,527	2,490	619,637	718,166
1960–61	9,974	3,430	1,126	6,100	20,630	28,294
1961–62	15,198	..	..	3,452	18,650	26,108
1962–63	56,089	1,350	6,211	8,554	72,204	95,377
1963–64	8,157	400	631,292	2,793	642,642	845,831
1964–65	19,688	..	218,007	3,385	241,080	450,280
1965–66	3,805	..	74,327	3,155	81,287	136,841

TABLE 2—IMPORTS OF ANISEED INTO INDIA

(Qty in kg. and Val. in Rs.)

	China	Hongkong	Malaysia	Viet Nam	Taiwan (Formosa)	Others	Total	
							Qty	Val.
1957	19,254	5,639	..	..	..	21,084	45,977	57,733
1958	5,537	813	..	..	..	12,295	18,645	33,878
1959	..	1,778	..	..	..	914	2,692	2,722
1960–61	288,419	76,499	..	..	..	22,357	387,275	416,001
1961–62	187,290	2,000	..	..	..	18,527	207,817	243,786
1962–63	12,058	..	..	..	..	312	12,370	15,185
1963–64	..	..	..	..	..	..	..	..
1964–65	18,458	25,060	1,830	..	..	5,384	50,732	62,402
1965–66	..	..	62,896	25,165	18,356	859	107,276	143,148

be cheaper than true anise (*Pimpinella anisum*) and most of the oil of commerce is said to be derived from it (Chopra, 1958, 219).

Aniseed possesses a sweet aromatic taste and emits, when crushed, a characteristic agreeable odour, and is used for flavouring food, confectionery, bakery products, beverages, anisette and other liqueurs. Fruits are considered mild expectorant, stimulating, carminative, diuretic and diaphoretic, and are used in flatulent colic, in the preparation of asthma powders and in veterinary medicine. Alcoholic extract of aniseeds possesses fungicidal activity (Parry, J. W., 88; Uphof, 279; I.P.C., 18; Claus, 1961, 235–36; *Chem. Abstr.*, 1947, **41,** 2260).

The chemical composition of aniseed varies with the origin of the fruits; the reported ranges of values are: moisture, 9–13; protein, 18; fatty oil, 8–23; essential oil, 2–7; sugars, 3–5; starch, 5; N-free extr., 22–28; crude fibre, 12–25; and ash, 6–10%. Choline is also present. The Indian Pharmaceutical Codex requires aniseed to contain: volatile oil, $\nless 2$; acid-insoluble ash, $\ngtr 1.5$; foreign organic matter, $\ngtr 1$; and other seeds and fruits, $\ngtr 2\%$ (Wehmer, II, 880; I.P.C., 18).

Aniseed is adulterated with exhausted fruits, fine earth and other small seeds and fruits. Ground aniseed is sometimes found adulterated with ground fennel which resembles it in aroma and flavour and is considerably cheaper (Krishna & Badhwar, loc. cit.; Parry, J. W., 88; I.P.C., 18).

Aniseed on steam distillation yields an essential oil, known as Oil of Anise, which now replaces the fruits for medicinal and flavouring purposes. Anise oil is a colourless or pale yellow liquid having the characteristic odour and taste of the fruit. It resembles very closely the oil distilled from star anise

(*Illicium verum*) but it has a finer and more delicate flavour, though the latter is commercially more important. Both aniseed and star anise are recognized by B.P. and U.S.P. as the official sources of anise oil (Krishna & Badhwar, loc. cit.; Guenther, IV, 563).

The yield of oil generally varies from 1.9 to 3.1 per cent; higher values up to 6 per cent have been reported from Syrian aniseed. Crushing of fruits prior to distillation gives better yields of oil; the material should be distilled soon after crushing to prevent any loss of oil due to evaporation. Anise oil is a highly refractive liquid which solidifies on cooling; the congealing point depends much on the anethole content and is a valuable criterion for evaluating the oil. Exposure of the oil to air causes polymerization, and some oxidation also takes place with the formation of anisaldehyde and anisic acid. The B.P. requirements of the oil are: congealing point, $\nless 15°$; sp. gr.$^{20°}$, 0.978–0.992; $n^{20°}$, 1.553–1.560; $[\alpha]_D$, $-2°$ to $+1°$; sol. at 20° in 3 vol. of 90% alcohol (Guenther, IV, 566–67; B.P.C., 1963, 46; B.P., 1963, 53).

The chief constituent of anise oil is anethole which is present to the extent of 80–90 per cent and is mainly responsible for the characteristic flavour of the oil. The oil also contains methyl chavicol, *p*-methoxyphenyl acetone, and small amounts of terpenes and sulphur-containing compounds of disagreeable odour. In addition, the following minor compounds have been identified in the Spanish oil: vanillin, anisaldehyde, anisalcohol, hydroquinone and its monomethyl ether, *p*-cresol, creosol, eugenol, propionic, butyric, myristic and anisic acids, cadalene and azulene (Guenther, IV, 569; Gildemeister & Hoffmann, VI, 426).

Oil of anise is used in perfumery, soaps and other toilet articles and for flavouring culinary preparations, confectionery, beverages and liqueur anisette. It is used in perfuming sachets, dental preparations and mouth washes; it is also used in the manufacture of lacquers (Hill, 454; Krishna & Badhwar, loc. cit.; *Perfum. essent. Oil Rec.*, 1962, **53**, 466).

Oil of anise is recognized by B.P. and Int. P. It is used as an aromatic carminative to relieve flatulence, and as an ingredient of cough lozenges in combination with liquorice. It is a mild expectorant and is used as an antiseptic, and for the treatment of cholera. It may be used in the preparation of gripe water. Oil is used externally as an insecticide against small insects such as head lice, mites and vermin; it has also fungicidal properties (I.P.C., 164; Thorpe, VIII, 655; Ooman, *Indian J. Pharm.*, 1950, **12**, 326; Merck Index, 743; *Chem. Abstr.*, 1956, **50**, 501).

The distillation water of anise is sold in Indian bazaars as *Araq badian* or *Araq saunf* and is reported to be used in medicine (Chopra, 1958, 220; Krishna & Badhwar, loc. cit.).

The residue left after extraction of oil may be used as a high grade cattle feed. It contains 17–19 per cent of protein and 16–22 per cent fat (Burkill, II, 1729; Chandrasena, 116).

Anise oil is frequently adulterated with the lower-priced star anise oil. In India, probably the oil of fennel is sold as a substitute for true anise oil: the former can be distinguished by its lower anethole content and higher optical rotation (+11° to +20°). Other adulterants used are turpentine oil, cedarwood oil, and copaiba and gurjun balsam oils. Adulteration with synthetic anethole made from pine oil is also reported (Krishna & Badhwar, loc. cit.; Guenther, IV, 568).

Ether extraction of the fruits (freed of essential oil) yields a dark green fatty oil having the following characteristics: $d^{20°}$, 0.9224; $n_D^{20°}$, 1.4718; acid val., 83.5; and unsapon. matter, 2.4%. The fatty acid composition of the oil is as follows: palmitic, 3.2; petroselinic, 23.5; oleic, 56.0; and linoleic, 17.1%. The oil is suitable for soap making. A hard fraction (yield 20%, m.p. 28.5–31.0°) of the oil can be used as a substitute for cacao butter in confectioneries and pharmaceutical preparations. The fatty oil expressed from the whole fruits possesses the characteristic anise flavour (Mensier, 450; *Chem. Abstr.*, 1959, **53**, 14548).

Fresh leaves of the plant are used as a garnish and for flavouring salads. They are eaten as pot-herb; they contain an essential oil and vitamin C (8.7 mg./100 g.) (Muenscher & Rice, 75; Gollan, 11; Parry, I, 501; Barua, *J. Indian chem. Soc.*, 1946, **23**, 238).

P. diversifolia DC. is a hairy or pubescent perennial herb, 60–150 cm. high, with compound leaves and white flowers, found throughout the Himalayas and Khasi, Aka and Lushai hills at altitudes of 900–3,000 m. and in Manipur. The herb is considered carminative (Kirt. & Basu, II, 1208).

P. heyneana Wall. ex Kurz is a slender erect annual herb, 30–90 cm. high, with fusiform root, 1–2-ternately compound leaves and white flowers, found in Chota Nagpur, Kalahandi (Orissa), Circars, Deccan, western ghats, Kanara and Konkan. The root of the plant is used in fever (Kirt. & Basu, II, 1207).

P. saxifraga Linn. is a biennial or perennial herb with a slender rootstock, pinnate radical leaves and pink or purplish flowers found in Kashmir at an altitude of 3,900 m. The Indian plant is considered as a distinct variety, var. *dissectifolia* C. B. Clarke (Fl. Br. Ind.), non Boiss.

The dried roots of *P. saxifraga* constitute the drug Pimpernel. It is aromatic, acrid and pungent and possesses diuretic and diaphoretic properties. It is used as a lithontriptic. It contains an acrid resin, volatile oil and a tasteless principle, pimpinellin. In indigenous medicine, the root is recommended for wounds, bleeding of nose and headache. A tincture is used as an antidiarrhoeic. An infusion of the plant is given to relieve flatulent indigestion. The root is also employed in liquor industry and spice extracts [Gathercoal & Wirth, 332 ; Kirt. & Basu, II, 1208 ; Hoppe, 676 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1953, **12A**(2), suppl., 284].

PINANGA Blume (*Palmae*)

A genus of slender palms distributed in the Indo-Malayan region. Eight species occur in India, and a few are introduced in gardens.

P. dicksonii Blume

Fl. Br. Ind., VI, 409 ; Blatter, 466.

Tel.—*Kondapoka ;* Kan.—*Kadu adike, jandarige ;* Mal.—*Kanakamuka.*

A slender graceful, soboliferous palm, 4.8–7.5 m. high and 5.0–7.5 cm. in diam., found in western ghats from North Kanara to the Nilgiri and Travancore hills at altitudes of 300–900 m. ; it is very gregarious and locally abundant in the evergreen forests of North Kanara. Leaves pinnate, forked: leaflets sessile, broadly linear ; spadix compound with 4–8 branches, clothed with imbricating flowers ; spathe simple, rigid, compressed ; fruit oblong, fibrous, 1.3–1.9 cm. long and 0.8 cm. diam. ; seeds ruminated.

The fruits of the plant are used as a substitute for betel-nut (*Areca catechu*). In China, Japan and Viet Nam, the dried husk of the fruit is given in flatulence, dropsy and obstructive diseases of the stomach ; it is also given in choleraic affections (Blatter, 467 ; Caius, *J. Bombay nat. Hist. Soc.*, 1934–35, **37**, 940).

Pine — *see* **Pinus**

Pine, Hoop or Norfolk Island — *see* **Araucaria**

Pine, Oregon — *see* **Pseudotsuga**

Pine, Screw — *see* **Pandanus**

Pineapple — *see* **Ananas**

Pineapple Guava — *see* **Feijoa**

Piney — *see* **Kingiodendron**

Piney Varnish — *see* **Vateria**

Pinnay Oil — *see* **Calophyllum**

PINUS Linn. (*Pinaceae*)

A large genus of monoecious, evergreen, resiniferous trees, commonly known as Pines, distributed in the northern hemisphere, extending south across the equator in Indonesia. Pines occur widely in the temperate regions ; in the warm temperate and subtropical countries they are found chiefly in the hills. Five species occur wild in India in the Himalayas and the hills of Assam. Several exotic pines have been introduced but not to an extent that they can be of any economic importance to the country.

Many species of *Pinus* yield valuable timber, used extensively for making furniture, railway sleepers, door and window frames, paper pulp, etc. The pine timber is divided into two main groups: Hard-Pines of the two- or three-needled species and the Soft-Pines of the five-needled species. In general, the heartwood in hard-pines is darker than the sapwood, while in the soft- or white-pines the colour of the wood is paler and more uniform. In India, *P. wallichiana* (*Kail*), a soft-pine, and *P. roxburghii* (*Chir*), a hard-pine, yield commercial timber. Equally important are the oleoresins exuded by several species of pines. On distillation, the resins yield an essential

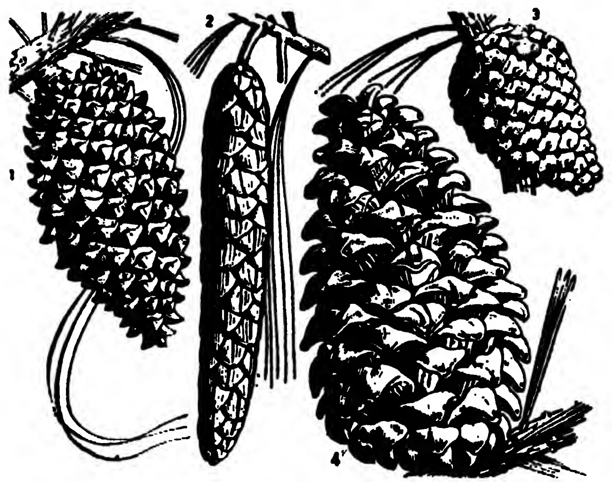


FIG. 26—CONES OF DIFFERENT PINUS SPP. : 1, P. roxburghii ; 2, P. wallichiana ; 3, P. insularis ; 4, P. gerardiana

oil, commonly known as Turpentine Oil or Turpentine, and a non-volatile product, the Rosin or Colophony. Turpentine oil is extensively employed as a solvent in paints and varnishes, while the rosin finds application in soap, detergent and synthetic pine oil industries. India produces large quantities of turpentine oil and rosin, mainly from *P. roxburghii*. Some of the pines yield edible seeds. *P. gerardiana*, found in the North-West Himalayas and Afghanistan, is the source of the much relished *Chilgoza* seeds (Streets, 464; Dallimore & Jackson, 444, 446; Troup, III, 1051).

P. gerardiana Wall. CHILGOZA PINE

D.E.P., VI(1), 240; C.P., 888; Fl. Br. Ind., V, 652; Troup, III, 1090, Fig. 440–41.

HINDI—*Chilgoza, neoza* (seeds).

N.W. HIMALAYAS—*Chiri, gunober, prita*.

A small to moderate-sized tree, occasionally attaining a height of 24 m. and a girth of 3.5 m., found locally in the inner arid valleys of the North-West Himalayas from Garhwal westwards at altitudes of 1,800–3,000 m. Branches somewhat ascending, usually not whorled; bark grey, exfoliating in irregular thin flakes; leaves in clusters of three, needle-like, 5–10 cm. long, stiff, dark green, partly persisting for 3–4 years; male cones 7.5–13.0 mm. long; female cones oblong-ovoid, 15–23 cm. × 10–13 cm. when ripe: scales thick, woody, about 3.8 cm. × 2.5 cm., reflexed; seeds cylindrical, pointed at the tip, 2.0–2.5 cm. long, dark brown, with a rudimentary wing; endosperm oily.

P. gerardiana has a rather peculiar distribution; while the tree is found in Afghanistan and Baluchistan and in the upper valleys of the rivers Chenab, Ravi and Sutlej, it is absent in the region which lies in between these two areas. In India, the tree grows gregariously forming more or less open forests, and is sometimes associated with *Cedrus deodara, Fraxinus xanthoxyloides*, and *Quercus ilex*.

The chilgoza pine is hardy and can withstand considerable cold and drought. It is a light-demander and is wind-firm. The tree is capable of growing on dry, barren, rocky hillsides with shallow soil and helps in the conservation of soil in the inner hills, which would otherwise be bare rocks. In its natural habitat the tree is usually found in dry regions outside the influence of the monsoon, where the rainfall is scanty but there is a heavy winter snowfall, and the total precipitation amounts to 37–75 cm. On exposed situations the trees remain stunted and gnarled: from the point of cone-bearing, however, stunted trees with spreading crowns are more valuable than shapely trees with narrow crowns (Troup, III, 1090–93).

Natural regeneration of the chilgoza pine suffers greatly from extensive and usually ruthless collection of cones for procuring the edible seeds and also indiscriminate grazing and browsing. Of the few ripe seeds reaching the ground, those falling under thorny thickets or in places protected from grazing come up readily. The main purpose of working the chilgoza pine forests being the production of the seeds, heavy thinnings to stimulate the expansion of the crown and a system of rotational closures to seed collection and grazing are best suited for successful regeneration. The rate of growth of the tree is moderate, with an annual girth increment of about 1.2 cm. (Troup, III, 1093; Gamble, 709).

The chilgoza pine is known to be affected by red-heart or pecky-rot caused by *Fomes pini* Lloyd. Several insect borers have been recorded on dead or fallen wood: *Dioryctria abietella* Schiff. and *Euzophera cedrella* Hampson bore into the cones [Puri, *Indian For. Bull., N.S.*, No. 179, 1955, 6; Mathur & Balwant Singh, ibid., No. 171(7), 1959, 30].

The tree flowers in May–June and the cones ripen during September–October of the following year. Depending upon the age and size of the tree, highly variable records have been made regarding the number of cones (28–129) per tree and the number of seeds (av. 33) per cone. As many as 400 cones have been recorded on a tree about 2.5 m. in girth. On an average 100 seeds weigh 30–35 g. (Troup, III, 1091).

Seeds—The seeds (Chilgoza) with edible kernels, are obtained from the ripe cones, which are plucked green before they open; on heating the cones the scales open and the seeds are shaken out. In the hilly and remotely situated areas, where the tree is found, the kernels form an important article of diet and the seeds are stored for winter use. In good seed-years, the surplus seeds are transported to the markets in the plains.

The chilgoza seeds are greatly valued as a dessert especially in northern India; the seeds are also credited with carminative, stimulant and expectorant properties. The kernels are eaten raw or roasted. Considerable quantities of the seeds are annually imported into India from Afghanistan and are sold in the Indian markets at a retail price of about Rs. 16–18 per kg. The chilgoza has a fairly stiff shell (testa) that can be easily separated from the kernel

which constitutes 65–70 per cent of the seed. The kernels are oleaginous and possess a delicate terebinthine flavour. Analysis of the kernels gave: moisture, 7.5; protein, 15.9; fat, 49.9; carbohydrates, 21.6; fibre, 2.2; and mineral matter, 2.9%. The mineral constituents of the kernel are as follows: calcium, 90.8; phosphorus, 92.4; and iron, 2.4 mg./100 g. Pectin is present to the extent of 1.73 per cent, calculated as calcium pectate (Hardikar, *J. Indian chem. Soc.*, 1928, **5**, 63; Khan & Chughtai, *Pakist. J. sci. Res.*, 1956, **8**, 155; Trehan & Bashir Ahmed, *J. sci. industr. Res.*, 1947, **6B**, 16).

The kernels have a high fatty oil content, up to 50 per cent. On pressing, a sample of kernels yielded 32 per cent of a transparent clear oil, having a pale-yellow colour and the following physico-chemical properties: sp. gr.$^{30^\circ}$, 0.9169; n^{25°, 1.4729; acid val., 5.3; sap. val., 192.4; iod. val. (Hanus), 119.7; acet. val., 3.5; Hehner val., 94.8; R.M. val., 0.22; thiocyanogen val., 83.2; and unsapon. matter, 0.4%. The fatty acid composition of the oil was as follows: palmitic, 3.7; stearic, 1.2; oleic, 52.3; and linoleic, 42.8%. The glyceride composition of the oil showed: palmito-dilinolein, 2.4; stearo-dilinolein, 0.8; palmito-oleolinolein, 9.9; stearo-oleolinolein, 3.2; trilinolein, 0.4; oleodilinolein, 32.5; dioleolinolein, 47.4; and triolein, 3.4%. The oil is said to be used for dressing wounds and ulcers [Kartar Singh & Tiwari, *Proc. nat. Acad. Sci. India*, 1943, **13A**(2), 120].

FIG. 27—PINUS GERARDIANA—CHILGOZA SEEDS AND KERNELS

Oleoresin—The chilgoza pine on tapping yields an oleoresin of good quality, but owing to its limited availability and avoidance of destruction of trees for obtaining the more valuable seeds, the species has not been exploited commercially for this purpose. The oleoresin is reported to yield about 35 litres/100 kg. of exceptionally good quality turpentine oil, which is pale yellow in colour and has a smell indistinguishable from that of American turpentine oil (from *P. caribaea* and *P. taeda*). Physico-chemical properties of the turpentine oil from *P. gerardiana* are given in Table 1. α-Pinene content of the oil is 70–80 per cent. The cones exude a copious white resin used locally for patching cracked wooden vessels (Simonsen, *Indian For. Rec.*, 1922–23, **9**, 345).

As the trees are only rarely felled, the pine yields no commercial timber. The wood (wt., 705–753 kg./cu.m.) is yellowish brown, hard and durable. It is somewhat similar to that of *P. roxburghii*, but is coarser and more resinous. It is scarcely ever used except for burning in the form of torches and as fuel. The bark is reported to be used for making baskets and buckets.

P. insularis Endl. syn. *P. khasya* Royle KHASI PINE
D.E.P., VI(1), 241; C.P., 888; Fl. Br. Ind., V, 652.

KHASI—*Ding-se, dieng-kysi*; LUSHAI—*Far*; BENGAL—*Saral*.

A medium-sized to tall tree with more or less whorled branches and a rounded crown, found in the Khasi, Jaintia, Lushai, Manipur and Naga hills of Assam, and in the N.E.F.A. It has also been introduced into the hills of North Bengal. It occurs at altitudes of 800–2,400 m. and under favourable conditions attains a height of about 45 m. with a girth up to 3 m. or more. Bark thick, reddish grey, deeply fissured, peeling off in flakes; leaves in clusters of three, 15–25 cm. long, slender, usually falling off during the second year; male flowers light brown; female cones solitary or in pairs, ovoid, 5.0–7.5 cm. × 4–5 cm. when ripe; seeds without wing 5–8 mm. long; wing about four times the length of the seed.

The Khasi pine thrives only on well-drained soils like granitic or sandstone rocks covered by reddish clay. At higher elevations, on exposed ridges and on shallow soil, the trees become stunted. It prefers fairly moist regions free from extremes of heat and cold with an annual rainfall of about 200 cm. The tree is a light-demander and wind-firm. Young trees are killed outright by fire, but the older ones are fairly well protected by the thick bark.

Natural regeneration—The pine comes up profusely on loosened soil in places of abandoned or shifting cultivation and in areas where the layer of dead needles and undergrowth have been burnt. Good seed-years are frequent and the seeds have a high percentage of fertility: fresh seeds show a germinating capacity of 95 per cent and those stored for a year, of about 65 per cent.

Artificial regeneration—It may be done by broadcast sowing shortly before the beginning of the monsoon, or by transplanting nursery-raised seedlings. The cones ripen about two years after their appearance. To obtain the seeds for sowing purposes, the ripe cones are collected during February-March. They are placed in the sun to open and the seeds are readily shaken out. About 1,500 seeds without wings weigh 28–30 g.

The plants raised in the nursery bear transplanting well. Seed is sown in March in the nursery beds and germination may commence after a few days or it may take a couple of weeks. When the seedlings are about 7.5 cm. high, they are pricked out in the nursery and planted early in the ensuing rainy season. The Khasi pine grows fairly fast. On an average it attains a height of about 30 m. and a girth of 1.8 m. in 60–72 years, giving an annual girth increment of 2.5–3.0 cm. (Troup, III, 1086–90).

Diseases and Pests—Khasi pine is affected by needle rust, *Coleosporium senecionis* Fr.; gall-rust, *Cronartium quercuum* Miyabe; and red-belt fungus, *Fomes pinicola* Fr. Larvae of a number of insect species bore into the newly felled or dead wood: larvae of *Lebeda nobilis* Walker and *Metanastria* spp. feed upon needles: beetles and larvae of *Blastophagus khasianus* Beeson, *Ips shanorum* Beeson, and *Polygraphus burmanicus* Beeson bore into the bark [Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 280; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171 (7), 1959, 31].

The Khasi pine is well adapted for silvicultural treatment in even-aged crops either by clear felling with artificial or even natural regeneration or by successive regeneration fellings with natural reproduction. A rotation of 60 years divided into four regeneration periods of 15 years each has been followed in Assam (Troup, III, 1088).

Oleoresin—*P. insularis* exudes an oleoresin of very good quality but as the tree covers only a small area and that too in remote places, it is not extracted for the production of turpentine on a commercial scale. The local people tap the trees by a traditional crude method. A hole is cut near the base of the trunk and a blaze, 120 cm. long and 30 cm. wide, is made above this notch. The resin exudes copiously from the blaze and is collected. The wood, at least near the blaze, becomes soaked with oleoresin. It has been estimated that a full-grown tree yields about 30 kg. of crude resin from one of these wounds and that the resin-encrusted wood contains another 16 per cent of its total weight of crude resin. The tree is then felled after about a year and the wood is chopped into small pieces for distillation of turpentine oil, using earthen vessels.

At present whatever little oleoresin of Khasi pine is extracted for commercial purposes, is obtained in much the same way as from *P. roxburghii* (q.v.). The average yield per tree (diam., 30–45 cm.) in the Khasi and Jaintia hills has been estimated to be 2.3–2.7 kg. per tapping season. The oleoresin is of a semi-solid or viscous consistency and possesses a light-yellow to white creamy colour and a fine odour. On steam distillation it yields 19–20 per cent (up to 23.4%) of turpentine oil and 65–70 per cent of rosin. A pilot plant for distillation of oleoresin from Khasi pine was set up in Khasi and Jaintia hills in 1953. The plant working at a capacity of processing 1.1 tonne of resin per day produced 18,160 litres of turpentine oil and 74,640 kg. of rosin in its first working year (Saikia *et al.*, *Curr. Sci.*, 1951, **20**, 275; Menon, 34).

Oil of turpentine from *P. insularis* is a colourless mobile liquid with a characteristic odour. Physico-chemical properties of the oil are given in Table 1. The composition of the oil recorded by various investigators differs widely. The oil of Burmese origin was found to contain 75.6 per cent α-pinene and 19.4 per cent β-pinene. The values obtained for the Indian oil ranged from 27 to 94.1 per cent for α-pinene and 2.6 to 11.7 per cent for β-pinene. Values obtained by vapour phase gas chromatography indicate that the Indian oil contains 30–40 per cent α-pinene and 60–65 per cent β-pinene (Saikia *et al.*, loc. cit.; Singh, *ISI Bull.*, 1968, **20**, 310).

TABLE 1—PHYSICO-CHEMICAL CHARACTERISTICS OF INDIAN TURPENTINE OILS

	Turpentine content of oleoresin, %	Sp. gr.	n_D	$[\alpha]_D$	Chemical constituents	References
P. gerardiana	39.6	0.8658 (at 30°)	1.468 (at 30°)	+18.4° (at 30°)	α-Pinene (73%), β-pinene (7%), sesquiterpenes and sesquiterpene alcohols	1
P. insularis	20.0	0.8633 (at 30°)	1.4675 (at 30°)	32.83° (at 30°)	α-Pinene (71.7%), β-pinene (11.7%), longifolene and sesquiterpenes	2
	..	0.8629 (at 26°)	1.4649 (at 28°)	−15.88° (at 26°)	α-Pinene (94.1%), β-pinene (2.6%)	3
	23.4	0.864–0.870 (at 15·5°)	1.473–1.476	−6.7° to −7.0°		4
	..	0.858–0.862 (at 30°)	1.4688–1.4750 (at 30°)	..	α-Pinene (30–40%), β-pinene (60–65%), camphene (1–2%), other terpenes (2–6%)	5
P. roxburghii	..	0.8658 (at 27°)	1.4755 (at 27°)	−14.35° (at 27°)	α-Pinene (24%), β-pinene (9.7%), Δ-3-carene (37.6%), longifolene (20.3%)	6
	..	0.8622 (at 22°)	1.4715 (at 27°)	8.29° (at 27°)	α- and β-Pinenes (c. 40%), Δ-3- and Δ-4-carenes (c. 50%), longifolene (5%)	3
	15–26	0.862–0.892 (at 20°)	1.473–1.479 (at 20°)	+2.14° to 5.2°	α-Pinene (20.8–36.2%), β-pinene (5.2–18.7%), camphene (1.2–5.5%), Δ-3-carene (44.6–67.5%), longifolene (up to 5.9%)	7
P. wallichiana	27.5	0.857 (at 30°)	1.4627 (at 30°)	+40.42° (at 30°)	α-Pinene (87.9%), terpineol, undecane and sesquiterpene	8
	22.8	0.8521 (at 35°)	1.4600 (at 35°)	+42.10° (at 35°)	α-Pinene (96.2%)	3

[1] Simonsen, *Indian For. Rec.*, 1922–23, **9**, 345; [2] Simonsen & Rau, ibid., 1922–23, **9**, 111; [3] Guha & Roy, *J. Indian Inst. Sci.*, 1941, **23A**, 201; [4] Saikia *et al.*, *Curr. Sci.*, 1951, **20**, 275; [5] Singh, *ISI Bull.*, 1968, **20**, 310; [6] Simonsen & Rau, *J. chem. Soc.*, 1923, **123**, 549T; [7] Parbhakar *et al.*, *Indian Oil & Soap J.*, 1963–64, **29**, 285; [8] Simonsen & Rau, *Indian For. Rec.*, 1922–23, **9**, 116.

The turpentine oil from Khasi pine is considered to be superior to that from *P. roxburghii* (q.v.) and is used for similar purposes. The use of this oil as a solvent for the extraction of quinine from cinchona bark with low-alkaloid content has been suggested (Saikia *et al.*, loc. cit.: Saikia, *Symposium on Essential Oils & Aromatic Chemicals,* Council of Scientific & Industrial Research, New Delhi, 1958, 32; Simonsen & Rau. *Indian For. Rec.*, 1922–23, **9,** 111).

The rosin obtained is a transparent golden-yellow solid with the following constants: sp. gr.$^{15.5°}$, 1.064–1.085; sap. val., 170.0–176.3; acid val., 166.6–173.4; and m.p., 70–72°. Rosin obtained from the Philippine samples is pale yellow when freshly prepared, has a slight aromatic odour, and contains 74 per cent of abietic acid (Saikia *et al.*, loc. cit.; Santos *et al.*, *Philipp. J. Sci.*, 1931, **45,** 383).

The bark contains 7–10 per cent of tannin [Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153].

Timber –The wood is intermediate in quality between *kail* and *chir* and is extensively used locally for building purposes. Sapwood is creamy white; heartwood light reddish brown, turning darker on exposure, with numerous conspicuous dark lines along the grain, denoting resin canals. The wood of Khasi pine is more resinous than that of chir. The heartwood is fairly straight-grained (though the grains are uneven), medium coarse-textured, moderately hard and somewhat light (sp. gr., c. 0.53; wt., 561 kg./cu. m.). The timber seasons well; green conversion and open stacking of the material in shade are recommended. It is easy to saw and work and is moderately durable under cover. The wood is used for indoor construction purposes. It is a good boardwood, suitable for planking and packing-cases. The wood is also employed for burning in the form of torches and as fuel (Pearson & Brown, II, 1042–44; Gamble, 708; Sekhar & Rawat, *Indian For.*, 1960, **86,** 617).

Investigations in the Philippines have shown that the digestion of wood by the Kraft process yields

49.6 per cent of pulp suitable for making bag- and wrapping-papers. The wrapping-paper produced is very much superior to other commercial papers and meets the U.S. Federal Specifications for Grades A and B kraft wrapping. The experimental bag-paper also compares favourably with commercial bag-papers and meets the requirements for Class A heavy-duty sack-kraft paper (*Philipp. Abstr.*, 1965, **6**, 83).

P. roxburghii Sarg. syn. *P. longifolia* Roxb. CHIR PINE, HIMALAYAN LONG-LEAVED PINE

D.E.P., VI(1), 242 ; C.P., 889 ; Fl. Br. Ind., V, 652 ; Troup, III, 1036, Fig. 416–20.

HINDI—*Chir, chil, sarala;* other vernacular and regional names are mostly derivatives of these names.

TRADE—*Chir, chil.*

A tall tree, with a spreading crown, found in the Himalayas from Kashmir to Bhutan and in the Siwalik hills at altitudes of 450–2,400 m. ; it comes up tolerably well in the plains also and is sometimes planted in gardens for ornamental purposes. Branches more or less whorled ; bark dark grey, often reddish, deeply fissured, rough, exfoliating in longitudinally elongated plates ; leaves in clusters of three, 20–30 cm. long, triquetrous, finely toothed, light green, persisting on an average for a year and a half ; male flowers about 1.5 cm. long, arranged in the form of cones ; female cones, solitary or 2–5 together, ovoid, 10–20 cm. × 7.5–13.0 cm. when ripe, brown, woody ; seeds winged ; without wing 7.5–13.0 mm. × 5.0–6.5 mm. ; wings long, membranous.

The chir pine occurs in the Himalayas almost exclusively in the outer hills and valleys, which receive the bulk of the rainfall during the monsoon, and it does not usually extend beyond the monsoon range. Though normally evergreen, it becomes deciduous or partly so in arid situations or during the dry seasons. The chir is a typically gregarious tree, forming pure forests over extensive areas, though it also often occurs mixed with other species, particularly towards its upper and lower limits of altitude. It is commonly associated towards the upper limit with *Cedrus deodara, Pinus wallichiana, Quercus incana, Rhododendron arboreum, Lyonia ovalifolia,* etc., while towards the lower limit the important ones are *Shorea robusta, Anogeissus latifolia, Ougenia oojeinensis, Buchanania lanzan,* and *Bauhinia* spp. The chir belt, in which the tree is found pure or nearly so over considerable areas occurs at altitudes of 600–1,500 m. (Troup, III, 1038).

The chir pine usually grows up to 30 m. in height and 2.5 m. in girth, with a cylindrical clean bole of about 12 m. Under favourable conditions, however, it may attain a height up to 54 m. with a girth of more than 3 m. In certain first-class localities, trees 45 m. in height and 3–4 m. in girth, with a clean bole of about 18 m., are by no means uncommon. On shallow soil, exposed ridges and other unfavourable situations, the trees are stunted, with tapering and often twisted or gnarled boles, and may not attain a height of more than 6–9 m. (Troup, III, 1037 ; Pearson & Brown, II, 1037).

In the pure chir belt, the absolute maximum shade temperature varies from 32 to 38° (90 to 100°F.), whereas the absolute minimum temperature falls below freezing point in most parts of the chir region. The normal range of rainfall in the major part of the chir belt is 100–175 cm., the bulk of which falls during the monsoon from July to September. During winter, besides some rains, there are occasional mild snow falls towards the upper limit of chir region.

The chir grows on a variety of geological formations. In the outer Himalayas it occurs on sandstone with occasional bands of clay or beds of conglomerate and in the valleys on quartzite. Other Himalayan formations on which the tree occurs are mica schist, gneiss, and shales, often with bands of quartzite ; in some localities it is found also on limestone. Chir is one of the least exacting of the Himalayan conifers, but it is intolerant of badly drained ground. It can grow on bare rock to an extent seldom seen in many other species, but the trees in such localities are often poorly developed. The consistency and depth of the soil and subsoil, however, appear to have a marked effect on the growth of the trees (Troup, III, 1044–46, 1054).

P. roxburghii is a pronounced light-demander, but in hot situations a certain amount of side shade may be necessary for the young trees. It has a massive root system and is more or less wind-firm. Though, in its natural habitat chir is not ordinarily exposed to severe frost, it has been found to be frost-hardy. Heavy snowfalls cause considerable damage to the trees which are somewhat brittle. Even though chir has great power of resistance to fire owing to its thick bark and recovers from the injury rapidly, nevertheless damage by fire in chir forests is considerable, as the tree is highly resinous and is found on hot, dry slopes (Troup, III, 1053–54).

Natural regeneration—It takes place through seeds. Under ordinary forest conditions, trees less than 30-years old seldom bear cones. The cones begin to

F.R.I., Dehra Dun

FIG. 28—PINUS ROXBURGHII—NATURAL REGENERATION

open during April–May of the third year, i.e. about 24 months after their appearance and the seeds get dispersed during April–July. Under natural conditions the seeds germinate as soon as sufficient moisture is available (Troup, III, 1047–48, 1061).

The chir is found abundantly and, to a great extent, regenerates the Himalayan forests. A certain amount of seed is produced almost every year, but a good seed-year occurs once in every 4–5 years. Normally, the germination commences at the beginning of the monsoon. The trees approaching maturity with a well-developed crown are selected as seed-bearers to effect complete regeneration. A number of factors, such as nature of seed-bearers, light, drought, topography and soil, soil covering and undergrowth, fire and grazing, and grass-cutting have considerable influence upon the extent and quality of natural regeneration; sufficient light and well-drained porous soils with a covering of burnt needles and ashes of other debris are generally very favourable for successful regeneration. After fire, the trees may regenerate by coppice also (Troup, III, 1061–70).

Artificial regeneration—It is required in areas where coniferous forests have been consumed by fire and in the abandoned sites of former shifting cultivation. In areas with twisted trees, artificial regeneration through the seed obtained from straight-grained stock would be preferable to cheaper natural regeneration from the existing badly twisted trees as this character is inherited through the seed (Champion & Trevor, 163).

Artificial regeneration of chir can be done through transplanting nursery-raised seedlings or by direct sowing. The mature cones are collected from trees during March–April, avoiding the trees with a twist. The cones are placed in the hot sun to loosen the scales, and thereafter the seeds are threshed out. Each cone yields roughly 50 seeds, and on an average 350 seeds weigh about 28–30 g. The seeds give 80–90 per cent germination with a plant survival of 37 per cent. About 500 g. of seeds give 1,500–1,700 plants for transplantation (Troup, III, 1048–50, 1068; Champion & Trevor, 73).

The seeds are sown in the nursery during March–April in shallow drills 15 cm. apart. The seedlings are pricked out in July, 15 cm. apart in lines about 23 cm. apart. One- or two-year old seedlings are usually transplanted at the beginning of the rains; in the second year the seedlings in the nursery are spaced at about 30 cm. x 40 cm. During transplanting parti-

cular care is necessary to avoid injury to the long tap-root. For artificial regeneration of chir for extensive afforestation purposes direct sowing is preferable, since in the Himalayas chir does not stand transplanting well. For direct sowing, seeds do not require any special preparation or treatment and are sown at the commencement, or a little before the break of the monsoon. Germination and plant survival percentages are normally high. A spacing of 1.5 m. × 1.5 m. is generally considered sufficient. Chir pine can be grown in the plains of northern India, if it can be made to survive the first hot weather drought. Air-layering two-year old branches during April–May has been successful (Troup, III, 1068–69; Dutta & Tomar, *Indian For.*, 1964, **90,** 196; Kedharnath & Dhaundiyal, ibid., 1963, **89,** 219).

The rate of growth of the chir seedlings is dependent on various conditions under which they grow. Under most favourable conditions five-year old plants begin to put on normal height-growth, but under less favourable conditions it may take 12–15 years. During the fifth season plants grown under nursery conditions attain a height of about 1.8 m., while the average height of natural forest plants is under one metre. The growth is maximum during spring (Troup, III, 1052–53; Champion & Trevor, 84).

The most suitable system of management of the chir pine is that of shelterwood compartment coupled with controlled burning of fallen litter in winter. Owing to its tendency to regenerate wherever possible in even-aged masses, chir is now mostly worked as even-aged forests under regeneration fellings by periods. Rotations adopted vary from 90–160 years and the regeneration periods from 20–35 years (Khan, *Indian For.*, 1943, **69,** 201; Troup, III, 1071–72).

The rate of growth of the chir pine varies greatly according to its habitat and other factors. Under suitable conditions the rate of growth is fast (annual girth increment 5.3–8.0 cm.) but in rocky, exposed sites, the rate of growth is much slower (annual girth increment 0.7–1.0 cm.). A large number of trees show an annual girth increment of 1.3–1.4 cm. The trees are ready for felling when they are about 40 years old and 12–20 m. in height (Gamble, 707; Troup III, 1083).

Three quality classes of chir crops are recognized according to height-growth data. There is, however, an inferior type of stunted chir, usually forming rather open crops, consisting of the trees seldom attaining a height of more than 20 m., even when 150 years of age. Such crops are hardly of any economic importance. Data concerning the growth and yield of the three quality classes of even-aged chir crops are summarized in Table 2 (Troup, III, 1079–80).

The areas under *P. roxburghii* in Himachal Pradesh, Jammu and Kashmir, Punjab and Uttar Pradesh and the annual out-turn of its timber in these States are respectively as follows: Himachal Pradesh—115,405 ha., 30,330 cu. m.; Jammu and Kashmir—158,813 ha., 7,050 cu. m.; Punjab—12,765 ha., 3,010 cu. m.: Uttar Pradesh—412,000 ha., 166,370 cu. m. (Information from the Central Silviculturist, F.R.I., Dehra Dun).

Diseases and Pests—The chir pine is affected by a number of rusts and wood-rot diseases. *Cronartium*

TABLE 2—GROWTH AND YIELD OF THE EVEN-AGED CHIR CROPS*
(Quality classes I, II & III)

Age (yrs)	Mean height (m.)			Mean diam. (cm.) (1.37 m. above ground level)			No. of trees per hectare			Final yield of stem timber per hectare (cu.m.)		
	I	II	III	I	II	III	I	II	III	I	II	III
20	9	6	5	10	4	2	2,491	3,707	..	0	0	0
40	19	14	10	26	18	11	541	877	1,443	150	24	0
60	27	21	16	39	30	21	282	390	526	337	179	73
80	34	27	21	50	41	33	180	217	272	479	308	180
100	38	31	25	61	52	44	133	143	158	568	382	245
120	41	34	27	66	59	51	119	116	119	612	416	268
140	42	35	27	68	62	55	111	109	104	643	440	281
160	43	35	28	69	62	56	111	106	101	657	459	283

* Howard, *Indian For. Rec.*, 1925 26, **12,** 164.

himalayense Bagchee, with its aecial stage as *Peridermium himalayense* Bagchee, attacks stems, causing blisters on the bark; the affected tree may die. *Peridermium orientale* Cooke attacks needles, but the damage is not very serious. *Hysterium pinastri* Schr. causes diseases of nursery seedlings; the needles are attacked, and badly affected seedlings die. Needle-rust caused by *Coleosporium campanulae* Lev. is also frequent, but the damage is not serious. Among the wood-rotting fungi *Fomes annosus* Cooke, *F. pini* Lloyd syn. *Trametes pini* Fr. and *Poria monticola* Murr. attack the living trees; *Fomes pinicola* Cooke, *Polystictus abietinus* Fr. and *Lenzites* spp. have also been recorded on the wood. A number of insect pests have been recorded on chir. *Chlorophorus strobilicola* Champion destroys the cones. Larvae of species of *Anomala, Granida, Hilyotrogus* and *Popillia* damage seedlings in the nurseries. Beetles and larvae of the species of *Cyrtepistomus, Athalia,* and *Pygaera* defoliate and the beetles belonging to the genera *Aetheomorpha, Aphthona* and *Colasposoma* gnaw the needles. Beetles and larvae of several insects of the family *Scolytidae* bore into the bark and young branches. Dead and fallen wood is attacked by a large number of borers, particularly the species of the genera *Anthaxia, Capnodis* and *Criocephalus* [Raizada & Sahni, *Indian For. Rec., N.S., Bot.*, 1960, **5**, 116; Puri, *Indian For. Bull., N.S.*, No. 179, 1955, 7; Mathur & Balwant Singh, ibid., No. 171(7), 1959, 31].

Turpentine Oil

Oleoresin from chir is the main source of turpentine oil in the country. There are two methods of tapping: (*i*) light-tapping, which consists of making a moderate number of blazes in the trees not to be felled in the near future; and (*ii*) heavy tapping, also termed "tapping to death". In heavy tapping as many blazes as possible are made on the trees which will be felled within five years. Normally, the tapping commences in March and continues till November, after which the flow of resin practically ceases. In the light-tapping cycle, the trees are tapped for a period of four years, followed by a rest period of eight years. The yield of resin varies greatly; it may be estimated at about 187 kg. per 100 blazes (Troup, III, 1076, 1078).

The present total production of oleoresin in the country is estimated at *c.* 45,000 tonnes per annum. The quantities of oleoresin produced in different States are given in Table 3.

For turpentine oil extraction, the crude oleoresin is first purified by melting in steam-jacketed containers, provided with spiral mixers, and removing the impurities such as chips and lighter particles which float to the top, and sand and silt which settle at the bottom. The clarified resin is then distilled in steam-jacketed or vacuum stills. The turpentine oil which collects in the top layer of the distillate is drawn off, passed through lime water to remove rosin acids, and rectified and fractionated into light (Grade I) and heavy (Grade II) grades. The oil is then dehydrated with common salt and anhydrous sodium sulphate. Before marketing, the dehydrated product is stored in tanks when any water still remaining over settles to the bottom and is drained off.

About 40 kg. of oleoresin yields on the average about 8.0 litres of first grade turpentine, 1.0–1.5 litres of other grades and 29–30 kg. of rosin; in other words, the average yield of total turpentine oil is about 22 per cent and that of rosin about 75 per cent of the oleoresin. The yields vary with localities, depending much upon the time of the year when the oleoresin is collected (Wlth India—Industrial Products, pt III, 227; Dutt, *Indian Oil & Soap J.*, 1960–61, **26**, 3).

Turpentine oil is a clear, transparent liquid with a pungent and somewhat bitter taste. On storage or exposure to air, the characteristic odour and taste of the oil become stronger and less pleasant. Table 1 gives the physico-chemical properties of the Indian turpentine oil from *P. roxburghii*. The average composition of the oil is: α-pinene, 20–30; β-pinene, 5–10; Δ-3-carene, 55–65; and longifolene and other terpenes, 2–10%. The presence of β-carene, β-longifolene ($C_{15}H_{24}$, b.p./9 mm. 126–28°) and longicyclene ($C_{15}H_{24}$, b.p./2 mm. 82°) has also been reported (IS: 533–1954; Parbhakar *et al., Indian Oil & Soap J.*,

TABLE 3—PRODUCTION OF RESIN IN DIFFERENT STATES*
(tonnes)

	1962–63	1963–64	1964–65	1965–66	1966–67†
Himachal Pradesh	8,743	13,865	8,781	9,768	14,736
Punjab	4,951	5,373	6,272	310‡	333‡
Jammu & Kashmir	3,316	2,870	3,088	n.a.	2,787
Uttar Pradesh	12,707	15,009	21,093	24,353	26,652

* Information from the Central Silviculturist, F.R.I., Dehra Dun.
† The total royalty received by the State Forest Departments in 1966–67 is stated to be Rs. 31.37 millions.
‡ Reorganized Punjab.

Photo : Naresh Bedi

PINUS ROXBURGHII—PLANTATION

1963–64, **29**, 285; Singh, *ISI Bull.*, 1968, **20**, 310; Ghatgey & Bhattacharyya, *Perfum. essent. Oil Rec.*, 1956, **47**, 122; Verghese & Gulati, *J. sci. industr. Res.*, 1951, **10A**, 112; Nayak & Sukh Dev, *Tetrahedron Lett.*, 1963, 243).

The quality of turpentine oil produced in the country varies considerably and depends upon the area from where it is obtained and the method of collection, storage and processing of the oleoresin. The Indian turpentine is characterized by its comparatively low pinene and high carene contents, and is similar to the Russian turpentine oil (from *P. sylvestris*) in some respects. Indian turpentine is considered inferior to the American product (from *P. taeda* and *P. caribaea*) due to its low pinene content; also it gets oxidized easily owing to the presence of carene and leaves a residue on evaporation due to the presence of longifolene. American turpentine consists almost entirely of α- and β-pinenes (Singh, loc. cit.; Finnemore, 94, 65; Menon, 34).

Uses—The Indian turpentine is chiefly used as a solvent, especially for thinning paints and varnishes. It is also used in pharmaceutical preparations, perfumery industry and in the manufacture of the synthetic pine oil, disinfectants, insecticides and denaturants. The Regional Research Laboratory, Hyderabad, has developed a process for the manufacture of chlorinated turpentine (60–80% chlorine), the insecticidal properties of which are reported to be comparable to DDT in its action against house flies, mosquitoes, and cockroaches. The chlorinated turpentine can be used as kerosene oil solutions, water dispersible pastes and powders. Denaturants for use in ethyl alcohol are produced from turpentine oil (Menon, 34; Bharat Bhushan & Husain Zaheer, *J. sci. industr. Res.*, 1953, **12A**, 287; Verghese & Yeddanapalli, *Chem. Age, India*, 1952, Ser. 5, 103; Ahmad *et al.*, *Pakist. J. Sci.*, 1961, **13**, 61).

The turpentine oil is one of the most important basic raw materials for the synthesis of terpene chemicals which are used in a wide variety of industries, such as adhesives, lubrication additives, synthetic resins, solvents, plasticizers, paints, varnishes, soaps, perfumery, cosmetics and paper and rubber chemicals. Most of these chemicals are based on α- and β-pinenes, which are separated from the oil by fractionation. The oil produced in India is, however, low in pinenes and, till recently, was not being used as a source material for these chemicals. A beginning has now been made for the recovery of its various constituents, particularly α-pinene of high purity for the manufacture of synthetic camphor and the intermediate product camphene. Several compounds useful in insecticide and perfumery industries, can be obtained from camphene. Δ-3-Carene, the major constituent of the Indian turpentine oil can be employed for the manufacture of terpineols, synthetic oil of pine, terpin-hydrate, etc., which were earlier produced from pinenes. Longifolene derivatives are increasingly used in the perfumery industry. An insecticidal preparation, longifolyl thiocyanoacetate, has given encouraging results as a contact poison against aphids. β-Pinene finds application in the manufacture of many products including synthetic resins and perfumery chemicals. In addition, fractionation of turpentine oil yields a number of other products including the valuable dipentene [Singh, loc. cit.; Sat Bir *et al.*, *Indian J. agric. Sci.*, 1959, **29**(4), 52].

The oil recovered after fractionation of α-pinene is known as the distilled oil of turpentine and contains predominantly Δ-3-carene. This pinene-free oil is reported to be comparable as a solvent to the natural turpentine oil and is being used by many industries.

The pine tar is produced by blending the terpenes available as by-products in the manufacture of synthetic camphor. It is being used by the rubber manufacturers in place of the imported product obtained by destructive distillation of the pine wood. The production of pine tar by destructive distillation of the wood is not feasible in the country because of the scarcity of pine wood supply and the poor economics of such a project (Singh, loc. cit.).

The turpentine oil is valued in medicine and is included in the Indian Pharmacopoeia and the Indian Pharmaceutical Codex under the name *Oleum terebinthinae*. Most of the therapeutic uses of the oil may be attributed to its local irritant action; it is also feebly antiseptic. During its elimination through the mucous membrane of the lungs it acts as an expectorant and is useful in chronic bronchitis; it is especially recommended in the treatment of gangrene of the lungs. It has been found beneficial as a carminative in flatulent colic. It is also used to arrest minor haemorrhages in tooth-sockets and nose. In the form of enema the oil is useful in obstinate constipation, tympanites and seatworm infestation. Externally it is used as a rubefacient in various rheumatic affections, such as lumbago, arthritis, and neuralgia. In the form of turpentine stupe it is used as a counter-irritant in various deep-seated inflammations, especially of the abdomen (I.P., 440; I.P.C., 192–93).

Grades and Production—The manufacture of turpentine oil from the chir pine is a well established industry in India. The Indian Standard on turpentine recognizes two grades, viz. Grade I and Grade II, the requirements of which are given in Table 4. Grade I is intended to cover the requirements of the material for pharmaceutical and perfumery purposes and is preferred for the manufacture of high class paints.

There are three units in the organized sector which are producing turpentine oil in the country, viz. (*i*) M/s Indian Turpentine & Rosin Co. Ltd., Bareilly, (*ii*) M/s Himachal Rosin & Turpentine Factory, Nahan, and (*iii*) The Government Rosin & Turpentine Factory, Miran Sahib, Jammu. The production of turpentine oil in the organized sector is given in Table 5. Besides these three units, there are about 20–25 small scale units which are producing turpentine. Reliable statistics relating to the output of the small units are not available, but it is estimated that their production of turpentine oil put together is equal to the combined output of the three units in the organized sector. The total production of the oil is sufficient to meet the internal demand (Information from the Directorate General of Technical Development, Govt. of India, New Delhi).

TABLE 4—INDIAN STANDARD SPECIFICATIONS FOR OIL OF TURPENTINE*

Characteristics	Requirements	
	Grade I	Grade II
Colour	Water white	(*a*)
Sp. gr. $^{30°}_{30°}$	0.8520–0.8620	0.8520–0.8720
$n^{30°}$	1.4680–1.4780	1.4680–1.4750
Acid val., max.	0.5	1.0
Residue on evaporation, % max.	1.0	2.0
Solubility:		
in 90% alcohol	7.0 vols.	7.0 vols.
in 95% alcohol	1.5 vols.	1.5 vols.
Distillation range:		
Running point, max.	Nil at 155°	1% at 150°
Stop point, min.	96% at 180°	85% at 180°
Flash point, min.	35°	35°
Unpolymerizable matter, % max.	6	11

* IS : 533 1954.
(*a*) Not darker than a freshly prepared solution of 0.001 g. of potassium dichromate made up to 100 ml. with distilled water acidulated with sulphuric acid.

The distilled oil of turpentine and the pine tar are produced only in one unit, namely Camphor & Allied Products Ltd., Bareilly, which was set up in 1964. These items are obtained as by-products in the manufacture of synthetic camphor. The production figures for distilled oil of turpentine during 1964, 1965 and 1966 were 868.9, 1,237.6 and 1,020.0 tonnes respectively. Annual consumption of pine tar in the country is estimated at 20,000 tonnes and till 1965 the entire quantity was imported (Singh, loc. cit.).

Pine Oil—The natural pine oil is obtained by steam distillation of the wood of *Pinus* spp.; it contains 5–10 per cent ethers and 20–25 per cent terpene hydrocarbons, the rest being terpene alcohols. Synthetic pine oil is manufactured from turpentine oil. A process (Indian Pat. No. 48429, 1952) has been developed by which pinenes, along with carenes and longifolene in turpentine oil, can be hydroxylated and esterified to give a mixture of terpeneols and terpene ethers, which are the main constituents of pine oil. The synthetic product,

TABLE 5—PRODUCTION OF TURPENTINE OIL, PINE OIL, AND ROSIN*

	Turpentine Oil†		Pine Oil		Rosin†	
	Qty (kl.)	Val. (thousand Rs.)	Qty (tonnes)	Val. (thousand Rs.)	Qty (tonnes)	Val. (thousand Rs.)
1960	2,794	1,676	60	240	12,211	20,026
1961	2,838	1,347	126	604	10,156	13,507
1962	3,263	3,447	143	535	13,633	20,926
1963	3,378	2,008	231	755	11,380	15,344
1964	3,297	3,297	348	1,148	13,658	16,619
1965	3,645	3,834	299	n.a.	13,385	18,895
1966	3,451	3,235	56	n.a.	12,631	13,380
1967	6,991	7,495	350	n.a.	13,545	16,961

* Information from the Directorate of Technical Development, Govt. of India, New Delhi.
† Production in organized sector.
n.a. not available.

obtained by this process in a yield of 40-50 per cent, is a light straw coloured, viscous liquid, with a characteristic pleasant odour and a bitter, slightly pungent taste; it contains 50 per cent terpene alcohols and 14 per cent terpene ethers. The synthetic pine oil is as good as the natural oil in its uses and, as a deodorant, it is even better than the natural product. The residual turpentine oil, recovered after the production of the pine oil, has superior keeping quality than the original oil, and can be used with advantage for the same purposes as turpentine.

The pine oil finds a wide range of industrial applications. It is used in paints, varnishes, lacquers, distempers, soaps and detergents, and in perfumery and pharmaceuticals. It is employed as a wetting agent in textiles, a degreasing agent in leather manufacture and as a synergist for insecticides. It also finds use in mining industry as a frothing agent to concentrate ore deposits by flotation process. It is suitable for use in the paper and rubber industries and in the preparation of floor waxes, furniture polishes, shoe creams, metal polishes and printing inks (*J. sci. industr. Res.*, 1956, **15A**, 199; Naik, *Industr. India Annual*, 1962, 179; *Res. & Ind.*, 1958, **3**, 202).

There is only one unit in the country (First Pine Oil Factory, Hoshiarpur), which is producing synthetic pine oil from turpentine. It has a capacity of 3,000 tonnes of pine oil per annum. Table 5 gives the production of pine oil in the country during recent years.

Rosin (Hindi -*Biroza*) The rosin is obtained as the solid residue in the distillation of the turpentine oil from the oleoresin. It is recovered from the still, after melting, by passing high pressure steam through the jacket. The molten mass is strained through filtering trays and filled into wooden casks, where it is allowed to cool for 1-2 days before marketing. The yield of rosin is about 75 per cent of the quantity of oleoresin distilled. The quantity and value of the rosin produced in the country in the organized sector is given in Table 5.

The rosin is faintly aromatic and occurs in the form of transparent or slightly translucent brittle lumps with a glassy structure. It is classified according to its colour into three types, viz. pale, medium and dark, which are further divided into eight colour grades. The Lovibond colour values of these grades, as prescribed in draft Indian Standards are given in Table 6. The rosin is soluble in ether, chloroform, light petroleum, alcohol, acetone, and most volatile and fixed oils. It consists mainly of a mixture of acids, partly in the form of anhydrides; the principal acid is abietic acid. A small amount of esters may be present. The rosin is not usually adulterated as it is probably one of the cheapest resins available in the market. The Indian Standard Specifications proposed for various types of rosin are given in Table 7 [ISI Doc: CDC 11 (3925), June, 1968—First Revision of IS: 553-1955; Thorpe, III, 295; Hill, 165].

The rosin is principally used in paper, soap, cosmetics, paint, varnish, rubber and polish industries. It is employed as an ingredient of printing inks, casein glues, and as a binder in plastics, dry battery and insulating compositions; it also finds application in linoleum and roofing cements. It is utilized in the manufacture of fireworks, match compositions, shell

TABLE 6—COLOUR STANDARDS PRESCRIBED FOR VARIOUS GRADES OF ROSIN*

Type	Grade	Lovibond colour value		
		Red	Yellow	Blue
Pale	X	1.35	13.0	
	WW	1.85	19.5	
	WG	2.6	30.0	
	N	3.6	41.0	
Medium	M	4.9	51.0	
	K	6.2	60.0	
	H	12.0	100.0	
Dark	D	75.0	160.0	3.0

* ISI Doc: CDC 11 (3925), June 1968 First Revision of IS: 553-1955.

TABLE 7—DRAFT INDIAN STANDARD SPECIFICATIONS FOR VARIOUS TYPES OF ROSIN*

Characteristics	Requirement for		
	Pale	Medium	Dark
Colour†	..	..	..
Softening point	55-65°	55-65	55-65°
Sp. gr.$^{30°}_{30°}$	1.05-1.08	1.05-1.08	1.05-1.10
Acid val., min.	160	160	160
Volatile matter, % max.	2.0	2.0	2.0
Ash content, % max.	0.5	0.20	0.50
Matter insol. in toluene, % max.	0.1	0.4	1.0
Unsapon. matter, % max.	6.0	6.0	6.0

* ISI Doc: CDC 11 (3925), June 1968- First Revision of IS: 553-1955.

† For colour requirements *see* Table 6.

Note: Additional requirements of rosin for rubber, soap, and other specialized uses are also prescribed in the Standard.

explosives, insecticides and disinfectants and enters into certain lubricating compositions and hair fixing and nail polishing preparations. The rosin is an ingredient of core oils and is also used as a flux in soldering and tinplating. It is applied to reduce slipping and also to bows of musical instruments for ensuring proper contact between the bow and the string. Rosin is employed in brewing and in mineral beneficiation as a frothing agent. It is utilized as a source of rosin oil, rosin spirit, rosin pitch and abietic acid (Wlth India—Industrial Products, pt III, 231; *For. Res. India*, 1952–53, pt I, 9).

Rosin Oil and Rosin Spirit—On destructive distillation the rosin yields 3–10 per cent of a lighter fraction, called rosin spirit or pinoline, and 80–85 per cent of a denser fraction, known as rosin oil. The rosin spirit is a pale yellowish oil (b.p. 70–250°) consisting of hydrocarbons and oxygenated substances. It is used as an illuminant and as a substitute for turpentine oil in the varnish industry. The rosin oil is a viscous brown liquid (sp. gr., 0.98–1.10) with a green fluorescence and consists of abietic acid ($C_{20}H_{12}O_2$), phenols, and complex hydrocarbons $(C_{10}H_{16})^n$. With lime it forms rosin grease, which is used as a lubricant in wagon and trolley wheels, and in various other types of machinery. The rosin oil finds application in the manufacture of printer's ink, varnishes and antiseptics. It is sometimes used as an adulterant for oils, especially boiled linseed, olive, rape and sperm oils. Use of the rosin oil as a binder for the production of micanite from mica splittings has also been suggested (Zutshi, *Indian Soap J.*, 1958–59, **24**, 92; Patel & Guha, *Curr. Sci.*, 1950, **19**, 128).

Pine Needle Oil—The young twigs and fresh needles and cones of several *Pinus* spp. yield a valuable essential oil, known as the pine needle oil; the term pine needle oil, as employed in trade, however, includes also the oils obtained from fir (*Abies* spp.) and spruce (*Picea* spp.) needles. The oil has a refreshing pine-wood odour and is used as an adjunct in the scenting of soaps, in bath preparations, room sprays, deodorants and similar products. It is produced on a commercial scale in a number of European countries. Although needles are available in India in large quantities from felled pine trees, they have not yet been exploited for this purpose. A profitable cottage industry can be developed if portable stills are installed in the felling areas and the oil distilled on the spot (Choudhary *et al.*, *Indian Oil & Soap J.*, 1959–60, **25**, 306; Guenther, VI, 245).

On steam distillation, the needles of *P. roxburghii*, collected from the hilly regions of Jammu & Kashmir are reported to give 0.26 per cent of a colourless volatile oil possessing a strong balsamic odour. The physico-chemical properties of the oil are summarized in Table 8. The oil contains α- and β-pinenes, Δ-3-carene, α-limonene, α-phellandrene, borneol, borneol acetate, longifolene and α-cadinene. Distillation of the green needles and green twigs, collected from Dehra Dun, gave oils in yields of 0.08–0.24 per cent and 0.27–0.62 per cent respectively. The oil obtained from the needles was pale yellow in colour, with a true balsamic odour and was of better quality than the oil from the twigs which was colourless and had turpentine like odour. The needle oil from *P. roxburghii* shows antibacterial activity against a number

TABLE 8—PHYSICO-CHEMICAL CHARACTERISTICS OF PINE NEEDLE AND CONE OILS

	P. roxburghii			*P. wallichiana*	
	Needles[1]	Needles[2]	Twigs[2]	Needles[1]	Cones[3]
Yield, %	0·26	0.08–0.24	0.27–0.62	0.5	..
Sp. gr.	0.8616 (at 25°)	0.8763–0.8873 (at 20°)	0.8703–0.8823 (at 20°)	0.8550 (at 30°)	0.8757 (at 15°)
$[\alpha]_D$	−8.7°	+2.5° to +12.25°	+6.33° to +11.5°	−17.4°	−32.75°
n_D	1.4732 (at 25°)	1.4799–1.4868 (at 20°)	1.4742–1.4785 (at 20°)	1.4700 (at 30°)	1.4735 (at 20°)
Acid val.	0.8	1.6–8.1	0.4–5.3	0.6	..
Esters (as bornyl acetate), %	4.8	7.7–13.0	5.4–8.0	2.5	2.0
Solubility in 90% alcohol	5 vols.	..	..	4 vols.	5 vols. or more

[1] Choudhary *et al.*, *Indian Oil & Soap J.*, 1959–60, **25**, 306; [2] Karnik *et al.*, *Indian For.*, 1964, **90**, 826; [3] Gildemeister & Hoffmann, IV, 218.

of organisms including *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhosa* and *S. paratyphi* (Choudhary *et al.*, loc. cit.; Karnik *et al.*, *Indian For.*, 1964, **90**, 826; Chopra *et al.*, *J. Amer. pharm. Ass., sci. Edn*, 1960, **49**, 780).

Pine Wool—The exhausted needles, after the extraction of the essential oil, can be converted into a fibrous material called pine wool. The needles are boiled in a two per cent caustic soda solution to loosen the resinous and non-fibrous materials which are subsequently separated by repeated beating. The needles are then thoroughly washed in running water and dried in the sun. The long thin fibres so obtained constitute the pine wool of commerce. They still retain the faint odour of the pine and can be bleached to a pure white colour. Pine wool is considered vermin-proof and is used for stuffing pillows, cushions, and mattresses. It is also suitable for use as a packing material for fruits (Batham, *Bull. Dep. Ind. & Comm., United Provinces, N.S.*, No. 30, 1942; Varma & Shukla, *Bull. reg. Res. Lab., Jammu*, 1962, **1**, 58).

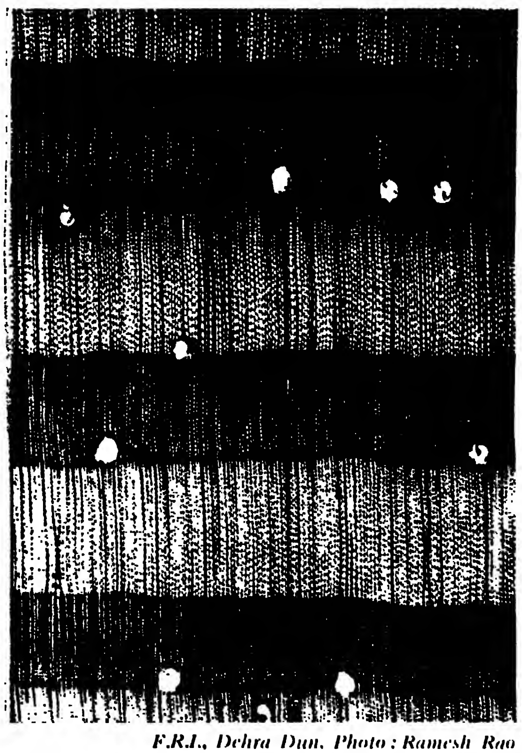
Timber

Chir is one of the most widely used commercial timbers in the hills and plains of northern India. Large quantities of it are floated down the rivers from the Himalayas for utilization in the plains.

The sapwood is white to creamy-white; the heartwood is light red when first exposed, turning reddish brown with age, with well marked annual rings and dark lines along the grain denoting longitudinal resin canals. The wood has a resinous odour when freshly cut. It is straight- or nearly straight- to strongly-twisted and uneven-grained, medium coarse-textured, and moderately hard and heavy (sp. gr., 0.58–0.68; wt., 529–609 kg./cu. m.). The chir wood is generally quite strong for its weight, but its strength is largely dependent upon the straightness of the grain. The wood with even a slight twist of the fibre is difficult to saw; badly twisted wood cannot be chopped easily even into fuel billets. Though it has not been possible to correlate the existence of twist with any particular factor, the trees with twisted fibre are more prevalent in Kumaun and Garhwal hills than in any other locality (Pearson & Brown, II, 1039–40).

The timber is not difficult to air-season if stocked in well ventilated open piles, preferably under cover. Rapid drying in the open gives rise to a certain amount of surface cracking, while close-piling in a damp atmosphere results in fungal attacks. Green conversion, followed by seasoning for about 12 months gives the best results. When sawing for sleepers, it is advisable to eliminate the wood from near the centre as it is liable to develop mild star-shakes. The chir wood can also be kiln-seasoned without much difficulty, though resin is liable to exude on the surface during the process; 2.5 cm. thick planks take 5–7 days to dry and require an initial steaming for 2 hours at 55°/100 per cent R.H. for sterilization (Pearson & Brown, II, 1040; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956).

The chir timber is not very durable in exposed situations; graveyard tests on natural durability showed a life of 2–5 years. It is, however, quite durable under cover. The wood lends itself readily to preservative treatment, both by open tank and pressure processes. It is easy to saw and work by hand or by machine, though its resinous nature tends to clog saw teeth. It can be brought to a fine smooth surface; paint and enamel finishes are preferred to shellac polish, as the latter dulls rapidly. The data for the comparative suitability of the wood expressed as percentages of the same properties of teak are: wt., 85; strength as a beam, 70; stiffness as a beam,



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 29—PINUS ROXBURGHII—TRANSVERSE SECTION OF WOOD (×10)

85; suitability as a post, 75; shock resisting ability, 80; retention of shape, 65; shear, 80; and hardness, 60 (Pearson & Brown, II, 1041; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Masani, ibid., 1964, **90,** 229; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 57, Sheet No. 16).

The wood is in great demand in northern India, and is an excellent all-round cheap timber of the deal class. It is used extensively for constructional purposes, such as rafters, posts, boarding, door and window frames and other house fitments, and occasionally as beams. It is also used for cheap joinery and furniture, packing cases, truck and bus bodies, cores of laminboards, and electric transmission poles. When treated with preservative, the wood can be used for railway sleepers with a life of about 17 years. It is also used in fair quantities for miscellaneous work in the construction of railway carriages and wagons (Pearson & Brown, II, 1041; Trotter, 1944, 151–52, 207–08, 215, 220–21; Masani, loc. cit.).

It is a good fuel wood and the timber from twisted useless trees is often used for making charcoal: calorific value: sapwood—4,967 cal., 8,941 B.t.u.: heartwood—5,063 cal., 9,114 B.t.u. (Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21; Puri & Gupta, *Indian For.*, 1954, **80,** 352).

The chir wood is a suitable raw material for making paper pulp. Analysis of the wood gave the following values (oven dry basis): cellulose, 53.5; lignin, 28.6; pentosans, 7.2; ash, 0.25; hot water extr., 3.4; alkali (1%) extr., 13.2; ether extr., 3.4; and alcohol benzene extr., 2.1%. Digestion of the wood chips by sulphate process (temp., 170°; period, five hr; consumption of chemicals, 21%; bleach consumption, 8%) gave bleached pulp in a yield of 40 per cent. The bleached pulp is reported to be suitable for making white writing and printing papers. Since the wood is long fibred (av. length, 3.6 mm.), its pulp is particularly suitable for admixture with short fibred pulps for the manufacture of wrapper paper. The wood waste, left after making sleepers, may be utilized for paper making; the logs are not economical for the purpose. The saw dust, mixed with sal bark, arecanut husk, or spent tea leaves can be pressed together to form boards (Guha, *Indian For.*, 1958, **84,** 235; Bhat & Man Mohan Singh, ibid., 1955, **81,** 765; Narayanamurti & Harcharan Singh, *Comp. Wood*, 1953–54, **1,** 121).

The bark contains 11–14 per cent of tannins. A yellow dye present in the bark colours leather catechuic brown. The cork of the chir bark can be used as a cheap insulating material. Thick bark lends itself easily to knife work; and small articles of decorative and ornamental value and utility, such as ash-trays, can be conveniently carved out. The bark at present goes to waste and its utilization for this purpose may open a new profitable handicrafts industry. The seeds are eaten by the inhabitants of hilly areas [Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153; Khan, *Pakist. J. For.*, 1957, **7,** 44].

P. wallichiana A. B. Jackson syn. *P. excelsa* Wall. ex D. Don: *P. griffithii* McClelland BLUE PINE, BHUTAN PINE

D.E.P., VI (1), 238; C.P., 888; Fl. Br. Ind., V, 651; Troup, III, 1015, Fig. 401 & 402.

HINDI—*Kail.*

KASHMIR—*Yiro, kaiar, kail;* HIMACHAL PRADESH—*Lim;* KUMAUN—*Raisalla, lamshing, byans, dolchilla;* LEPCHA—*Neet-kung;* BHUTAN—*Tongschi, lamshing.*

TRADE—*Blue pine, kail.*

A tall evergreen tree with spreading or drooping branches, found in the Himalayas from Kashmir to Bhutan at altitudes of 1,800–3,700 m.; it also occurs in Balipara tract of Assam. Bark smooth and resinous in young stems, turning grey and corky with shallow fissures on mature trees; leaves needle-like in clusters of five; abnormal fascicles containing 4, 6 or 7 needles are occasionally found: needles 10–20 cm. long, bluish green, glaucous, persisting partly for 2–3 years; male flowers catkin-like, arranged in a cluster, yellow to light brown, often pink towards the apex; mature female cones lateral, solitary or in groups of 2 or 3, cylindrical, ripening after 18 months of their appearance, 15–33 cm. × 4–5 cm. when ripe, light brown, very resinous and easily distinguishable from other pines; seeds ovoid, 6–10 mm. long (without wings): wings membranous and about thrice as long as the seed.

The blue pine occurs throughout the temperate Himalayas, though it is rarely met with in Sikkim and a considerable part of Kumaun. Its altitudinal range is higher than any other Himalayan conifer. In the western Himalayas at altitudes between 1,800 and 2,500 m. the tree is typically gregarious, often forming extensive pure crops, owing to its capacity to come up in dense even-aged masses, on open hill sides and on abandoned cultivated tracts. Towards the lower elevations the tree descends to about 1,200 m., where *P. roxburghii* may be the associate species. In spite of its tendency to form pure crops, the blue pine

frequently occurs mixed with other trees, such as deodar, spruce, silver fir, oaks, *Rhododendron arboreum, Lyonia ovalifolia, Populus ciliata, Cornus macrophylla, Prunus padus, Cedrela serrata, Ulmus wallichiana,* etc.

The young vigorously growing trees have a very graceful appearance, but as the trees become old they tend to become ragged. Under favourable conditions, trees having a height of 36 m. with a girth of 2.5-3.0 m. and a straight bole of about 18 m. are not uncommon; trees with larger dimensions are also met with. At higher elevations the blue pine ascends into the region of birch and juniper: in this region the trees are stunted, often broken and bent, giving a shrubby appearance. On poor shallow soil and exposed situations the trees do not attain a height of more than 15 m. Though the root system of the blue pine is superficial, it is massive and the tree is windfirm (Troup, III, 1015-16, 1024; Raizada & Sahni, *Indian For. Rec., N.S., Bot.,* 1960, **5**, 111).

In the region of the blue pine the absolute maximum temperature may be placed slightly over 37.8° (100°F.), while the absolute minimum towards its upper limits is near −18° (0°F.). The annual rainfall varies from 100 to 190 cm. Throughout its habitat heavy snowfall occurs during winter.

Like the chir, the blue pine is also found in a variety of geological formations, thriving on moist deep soil with good drainage. In its natural habitat the tree tends to occupy the warmer slopes and spurs. At some places it also springs up in abundance on boulder and gravel deposits in the beds of the rivers and on places of abandoned cultivation, showing its preference for porous soil with sufficient subsoil moisture. Some of the best forests of the blue pine are found on mica schist, which decomposes into ideal soil. On shale the growth of the trees depends on the hardness of the rock and depth of the soil; where the soil is shallow the growth of the trees is stunted (Troup, III, 1018; Raizada & Sahni, loc. cit.).

The blue pine is a strong light-demander, though it may persist in shade for a number of years. Young plants are capable of pushing their way up, provided the shrubby growth is not too heavy. The species suffers from snow; the crowns break and the young trees develop curvature at the base. Snow-break is particularly common in dense pole crops. Early thinnings carried out lightly at frequent intervals, is the best preventive measure. The blue pine is very sensitive to fire since it does not have a thick and protective bark like *P. roxburghii*. The pole crops are killed outright and the large trees also often succumb to fire (Troup, III, 1024–25, 1028).

Natural regeneration—Under favourable conditions, given abundance of light and protection from fire and grazing, the blue pine regenerates profusely, as the seeding conditions of this pine are particularly good, viz. (*i*) fertile seed commences to be produced at an early age of about 10–15 years; (*ii*) good seed-years are frequent; (*iii*) sufficient seed for complete regeneration of the area is produced; and (*iv*) there is hardly any year when a fair proportion of trees in a blue pine forest do not bear seed.

The female cones mature in the second year; the scales open and the seeds are shed during September–November. They remain unsprouted till the ensuing rainy season. About 25 seed-bearers per hectare are retained; on hot slopes, however, the number may increase to 50. Seedlings, under average natural forest conditions, attain a height of 13–20 cm. in four years (Troup, III, 1026–27, 1031, 1023).

Artificial regeneration—Direct sowing is preferred to transplanting. On an average a cone yields about 100 seeds and about 500 seeds weigh 28–30 g. Tests carried out at Dehra Dun showed that the seeds retain their viability for a period of about eighteen months. The seeds are sown in November and 2–3 year old seedlings transplanted during the rainy season at a spacing of 1.5 m. × 1.5 m., or 1.2 m. apart in contour lines 2.5-3.0 m. apart. Nursery-grown seedlings, which come up under more favourable conditions, reach a height of 23-38 cm. in three years. They have stout stems and well developed masses of adult needles (Troup, III, 1021-24, 1029-30).

The rate of growth under favourable conditions is rapid in the young trees; when they reach maturity the growth in girth becomes slow while height-growth may almost cease. In good soils at a moderate elevation, 4–5 growth rings are present in a radius of 2.5 cm. (an annual girth increment of 3.3-4.0 cm.); at higher elevations or on rocky ground, however, the growth is slow with 20-25 rings for the same radius (annual girth increment of 0.6–0.7 cm.). The blue pine reaches its maturity in 120–180 years, after which the trees are likely to become unsound in the centre; at the higher elevations and in the dry areas, however, it may remain sound for a longer period (Troup, III, 1033; Gamble, 704–05).

Regeneration of the blue pine can be managed under uniform system for deodar and blue pine. For regeneration of mixed deodar and blue pine, a certain

amount of deodar regeneration is secured first by moderately opening the canopy and then opening out drastically with the object of filling in the gaps in the young deodar crop with blue pine. In the first half of its life the blue pine outstrips deodar in both girth and height. In Kulu forests, where the blue pine and deodar are mixed, a provision of a regeneration period of about 30 years is made. Where pure blue pine crops are concerned, the regeneration period is ordinarily fairly short (Champion & Trevor, 313; Troup, III, 1031–33).

Like the chir crops, three quality classes, based on height-growth data, are recognized for *P. wallichiana*; the data concerning the growth and yield of the three quality classes of even-aged *kail* crops are given in Table 9.

The acreage under the blue pine and the outturn of its timber in Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh are respectively as follows: Himachal Pradesh—88,519 ha., 174,480 cu.m.; Jammu and Kashmir—181,704 ha., 97,000 cu.m.; Uttar Pradesh—16,132 ha., 3,860 cu.m. In the Punjab there is hardly any production of timber from this species (Information from the Central Silviculturist, F.R.I., Dehra Dun).

Diseases and Pests—Among fungi causing decay of the timber, the important ones are *Lenzites subferruginea* Berk., *L. sapiaria* Fr., and *Polyporus schweinitzii* Fr., which cause brown rot and *P. adustus* Fr. and *P. circinatus* Fr., which cause white rot. *Fomes pini* Lloyd syn. *Trametes pini* Fr. causes heart rot in standing trees. The rusts on the tree include *Cronartium ribicola* Fischer, the aecial stage of which, *Peridermium indicum* Colley & Taylor, attacks mostly seedlings and saplings between 3 and 10 years of age. *Peridermium brevius* Sacc. attacks needles of young plants which become suppressed and die. *Melampsora oblonga* Bagchee attacks needles severely. The beetles and the larvae of *Hylobius angustus* Faust damage saplings. The larvae of the moths *Dioryctria abietella* Schiff. and *Euzophora cedrella* Hampson bore into the green cones and cause serious damage [Raizada & Sahni, loc. cit.; Troup, III, 1025; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 28].

Oleoresin and Turpentine Oil—The yield of oleoresin from the blue pine is low, being about half of that from the chir pine, but the turpentine oil obtained is of superior quality. On distillation the crude oleoresin gives 27.5 per cent of turpentine oil which has a high pinene content (88%) and is suitable for all purposes where the American turpentine oil can be used. A sample of the oleoresin, collected from Chakrata, yielded 22.8 per cent of turpentine oil of an exceptionally good quality, with a pinene content as high as 96.2 per cent. Table 1 gives the physico-chemical properties of turpentine oil from the blue pine. The amount of rosin recovered is about 68 per cent of the oleoresin. Rosin oil is obtained in a yield of 75 per cent when the rosin is subjected to destructive distillation. It contains cymene, *p*-cymene, *p*-xylene, toluene and propionic acid, which have not been reported in rosin oils from other pines (Dutt, *Indian Oil & Soap J.*, 1960–61, **26**, 3; Simonsen & Rau, *Indian For. Rec.*, 1922–23, **9**, 116; Guha & Roy, *J. Indian Inst. Sci.*, 1941, **23A**, 205; Patel & Guha, *Curr. Sci.*, 1950, **19**, 128).

Needle Oil—The needles from *P. wallichiana* on steam distillation yield 0.5 per cent of a pale yellow essential oil which can be used for the same purposes as the needle oil from *P. roxburghii* (q.v.). The oil obtained from the blue pine needles consists mostly of hydrocarbons; the constituents identified are α- and β-pinenes, α-limonene, α-phellandrene, dipentene,

TABLE 9—GROWTH AND YIELD OF EVEN-AGED KAIL CROPS*
(Quality Classes I, II & III)

Age (yrs)	Mean height (m.)			Mean diam. (cm.)			No. of trees per hectare			Final yield of stem timber per hectare (cu.m.)		
	I	II	III	I	II	III	I	II	III	I	II	III
20	10	7	5	11	7	4	1,764	3,015	4,379	0	0	0
40	21	17	13	27	19	14	702	998	1,347	205	108	50
60	31	25	20	41	32	25	442	576	717	601	379	238
80	38	31	25	51	43	35	344	410	494	950	671	449
100	41	35	29	57	49	41	297	358	420	1,122	881	634
120	42	36	30	61	52	45	267	326	386	1,192	957	731

* Champion *et al.*, *Indian For. Rec.*, 1927–29, **13**, 430–35.

borneol, terpineol, α-cadinene, and azulene. The oil shows antibacterial activity against a number of organisms including *Staphylococcus aureus, Salmonella paratyphi* and *Proteus vulgaris.* A pale yellow essential oil can also be distilled from green cones. Physico-chemical characteristics of the pine needle as well as the cone oil are summarized in Table 8 (Choudhary *et al., Indian Oil & Soap J.*, 1959–60, **25,** 306; Simonsen, *Indian For. Rec.*, 1922–23, **9,** 341; Chopra *et al., J. Amer. Pharm. Ass., sci. Edn,* 1960, **49,** 780; Gildemeister & Hoffmann, IV, 218).

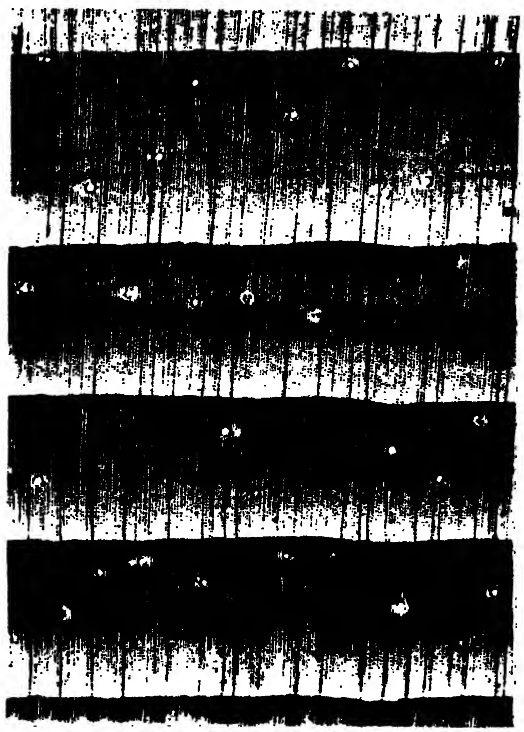
The seeds collected from Yamuna Forest Division, Kanpur, gave 20.2 per cent of a drying fatty oil with the following characteristics: sp. gr.$^{30°}$, 0.9223; $n^{40°}$, 1.4722; sap. val., 191.0; iod. val., 167.0; acid val., 0.72; Polenske val., 0.1; and unsapon. matter, 0.96%. The fatty acid composition of the oil was as follows: palmitic, 7.6; stearic, 6.5; oleic, 13.3; linoleic, 52.1; and linolenic, 20.3%. The oil is considered to be suitable for use in paints and varnishes [Om Prakash *et al., J. Oil Technol. Ass. India,* 1957, **13**(1 & 2), 47].

Timber

The blue pine timber is next to deodar in commercial importance. The main centres of supply of this timber are Kashmir, Himachal Pradesh and Uttar Pradesh. The sapwood is whitish; the heartwood light pink to red with darker striations, resinous, straight and fairly even-grained, medium fine-textured, soft and moderately heavy (sp. gr., 0.5: wt., 513 kg./cu. m.). The wood is lustrous when freshly exposed, becoming more or less dull with age. It seasons well and is not so liable to twist and warp as that of *P. roxburghii.* The logs are generally converted soon after felling. About 2.5 cm. thick planks take 5–7 days for kiln drying and require an initial steaming for about two hours at 55°/100 per cent R.H. to sterilize the wood and kill mould growth.

The wood of the blue pine is fairly durable under cover, but not so durable as that of deodar in exposed positions. It is said to last 7–8 years as shingles, 8–10 years as beams in walls and 15 years as inside planking. The life of blue pine sleepers, treated by open tank process, is about 14 years, but the wood is not easily amenable to treatment. Graveyard tests have shown a natural durability of 2–4 years. It is one of the timbers easiest to saw, machine and bring to a good finish. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 75; strength as a beam, 55; stiffness as a beam, 60; suitability as a post, 60; shock resisting ability, 55; retention of shape, 75; shear, 65; and hardness, 40 (Pearson & Brown, II, 1034–36; Purushotham *et al., Indian For.*, 1953, **79,** 49; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 57, Sheet No. 16; Limaye & Sen, ibid., 1953, **1,** 94; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956).

The timber finds many uses, and of the Indian pines, the wood of the blue pine is considered to be the best. It is used for internal fittings of residential houses, such as planking, door and window frames, panels and furniture; for these purposes it is preferred to deodar as it has less pronounced odour and does not pick up dust like the oily deodar wood. The wood after treatment is commonly used for making packing cases, camp furniture, drawing boards, fermentation vats and lorry bodies and shingles and railway sleepers. It is also utilized for making cheap pencils, battery separators, violins and match-boxes; the stumps are used for burning as torches. It is a good fuel wood and yields excellent charcoal: calorific value, 4,995 cal., 8,991 B.t.u. (Pearson & Brown,



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 30—PINUS WALLICHIANA—TRANSVERSE SECTION OF WOOD (×10)

II, 1036–37; Trotter, 1944, 151–52, 207, 215, 222; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945; Rehman *et al.*, *Indian For. Bull., N.S.*, No. 184, 1955, 18; Krishna & Ramaswami, ibid., No. 79, 1932, 21).

Laboratory and pilot plant studies have shown that the *kail* wood, in admixture with the deodar, silver fir and spruce woods, is suitable for the manufacture of bleached and unbleached kraft papers by the sulphate process. Digestion of the mixture of woods (32% *kail*, 22% deodar and 46% silver fir and spruce) gave unbleached pulp yields of 46–64 per cent and bleached pulp yields of 43–52 per cent with satisfactory strength properties. Digestion of the *kail* wood alone by the sulphate process, using 24 per cent chemicals at 170° for 4½ hours gave 39.4 per cent of bleached pulp with the following strength properties: breaking length, 5,580 m.; stretch, 2.3%; tear factor, 75.9; burst factor, 38.1; and double folds, 90. The fungus-attacked wood gave only 30.6 per cent of bleached pulp with inferior strength properties (Guha & Man Mohan Singh, *Indian For.*, 1960, **86**, 563; Guha *et al.*, ibid., 1964, **90**, 442; Man Mohan Singh & Guha, ibid., 1965, **91**, 199).

The bark contains a fair amount of colouring matter and is sometimes used for dyeing silk and wool; it gives a fine yellow colour on corah silk and deep orange on wool. It is also employed for roofing huts. The needles are mixed with plaster and employed in house construction. In winter, the needles may exude sweet manna, which is edible and used for adulterating honey. The roots yield an oil which is applied by the workers in the paddy fields to keep off water insects (Dallimore & Jackson, 575).

P. armandii Franch. (ARMAND'S PINE) is a tree, about 18 m. tall, distributed in the central and western China and Formosa, and also recorded from N.E.F.A. The needles are borne in clusters of five and closely resemble those of *P. wallichiana*. The seeds are wingless, 13–16 mm. long, and are edible (Kingdon-Ward, *J. R. hort. Soc.*, 1952, **77**, 207; Dallimore & Jackson, 446).

P. merkusii Jungh. & De Vriese is a tree, up to 30 m. high, distributed from the southern Shan States (Burma) to Indonesia and the Philippines. It has been recommended that the species may be introduced into the Nicobar and Andaman islands to cover the eroded hill slopes. The wood (wt., 689 kg./cu.m.) saws easily, works to a good finish and takes a fine polish. It is a useful general construction timber for indoor work (Pearson & Brown, II, 1044–46; Raizada & Sahni, *Indian For. Rec., N.S., Bot.*, 1960, **5**, 118).

Exotic pines, reported to have been successfully grown in various parts of India, are mentioned in Table 10. In their native countries, they are used for various purposes. *P. canariensis* C. Sm. is tapped for resin and its timber is used for building purposes,

TABLE 10—EXOTIC PINES SUCCESSFULLY TRIED IN INDIA*

Species	Common names	Native country	Area where tried
P. canariensis C. Sm.	CANARY ISLAND PINE	Canary Islands	Srinagar
P. caribaea More	HONDURAS PINE, CARIBBEAN PITCH-PINE	Caribbean region	Assam, Dehra Dun
P. cembroides Zucc. var. *edulis* Voss.	TWO-LEAVED NUT-PINE	Mexico to Colorado	Nilgiris
P. halepensis Mill.	ALEPPO PINE	Mediterranean region	Srinagar
P. massoniana Lamb.	MASSON'S PINE	China	Kulu, Manali, Raman
P. nigra Arnold var. *calabarica* Schneid. syn. *P. laricio* Poir.	CORSICAN PINE	Southern Corsica	do.
P. patula Schlecht. & Cham.	PATULA PINE	Mexico	Kulu, Manali, Natuhat Plateau, Palamau, Raman
P. pinaster Ait.	CLUSTER PINE, MARITIME PINE	Mediterranean region	Kulu, Manali, Rahini
P. radiata D. Don	MONTEREY PINE	U.S.A. (Pacific Coast)	Nilgiris
P. sabiniana Doug.	DIGGER PINE	U.S.A.	do.
P. taeda Linn.	LOBLOLLY PINE	U.S.A.	Kulu, Manali, Rahini
P. thunbergii Parl.	JAPANESE BLACK-PINE	Japan	Samunder, Takhdah

* Sahni, *Indian For.*, 1965, **91**, 55–56; Krishnamurthi, 221–22; Din, *Unasylva*, 1958, **12**, 128.

TABLE 11—PHYSICO-CHEMICAL CHARACTERISTICS OF TURPENTINE OIL FROM SOME EXOTIC PINES TRIED IN INDIA

Species	Turpentine content of oleoresin, %	Sp. gr.	$[\alpha]_D$	n_D	Constituents of the oil
P. canariensis[1]	27.0	0.8552 (at 20°)	+0.91° (at 22°)	1.4627 (at 27.5°)	*dl*-α-Pinene, l-limonene, dipentene, *d*-bornyl formate, a sesquiterpene
P. caribaea[1]	17.9	0.8632 (at 15.5°)	29.77° (at 24°)	1.4703 (at 20°)	l-α-Pinene (61.5%), l-β pinene (34%)
P. cembroides var. *edulis*[2]	20.0	0.8680 (at 15°)	+19.27° (at 20°)	1.4707 (at 15°)	α-Pinene (70–75%), β-pinene (5%), α-cadinene (15–20%)
P. halepensis[1]	20.0–23.0	0.8561–0.8591	+40° to +49°	1.4660–1.4699	l-α-Pinene (90%), l-limonene (4%), sesquiterpenes (1.5%)
P. nigra var. *calabarica* syn. *P. laricio*[1]	17.5	0.8618 (at 15°)	−39.4°	1.4696	l-α-Pinene (96%), *d*-limonene (1%), ester and other products (2%), sesquiterpenes (1%), carene, β-pinene
P. pinaster[1]	20.0–25.0	0.860–0.871 (at 15°)	29° to 33°	1.467–1.471	α-Pinene (63%), β-pinene (26.5%), dipentene, *d*-limonene, caryophyllene, longifolene, pinolhydrate, pinol, a ketone and a sesquiterpene
P. radiata[1]	16.0	0.8596 (at 23°)	5.85°	1.4727 (at 22°)	*dl*-α-Pinene (75%), l-β-pinene (22%)
P. sabiniana[2]	11.4	0.6971 (at 15°)	..	1.3903 (at 15°)	*n*-Heptane (95%), normal aldehydes (5%)
P. sylvestris[1,3,*]	..	0.864–0.86 (at 15°)	+7.7° to +26°	1.489	α-Pinene (60–80%), β-pinene (7–9%), Δ 3-carene (14–20%), sesquiterpenes (5%)
P. taeda[1]	18.6	0.8570 (at 22°)	+20.17°	1.4675 (at 27.5°)	*d*-α-Pinene (85%), l-β-pinene (12%)

[1] Gildemeister & Hoffmann, IV, 123–24, 74, 72, 67–69, 120, 80, 121; [2] Guenther, VI, 282, 285; [3] Thorpe, XI, 761.
* Introduction unsuccessful.

furniture and joinery; *P. caribaea* More is a good source of commercial resin; *P. halepensis* Mill. is extensively grown as wind-breaks and for soil conservation and sand fixation; *P. nigra* Arnold var. *calabarica* Schneid. has been widely used, mainly on short rotations, for pulp wood and mine props; *P. pinaster* Ait. is one of the main commercial sources of resin and its timber is used for telegraph poles and railway sleepers; *P. taeda* Linn. is utilized for wood pulp and ship-building and as a source of American turpentine oil; and *P. thunbergii* Parl., essentially a maritime species, is one of the most important timber trees of Japan, used for heavy construction, interior finish, box-boards, sleepers, etc. *P. cembroides* Zucc. var. *edulis* Voss. and *P. sabiniana* Doug. yield edible seeds. The physico-chemical properties of turpentine oils from these exotic pines are given in Table 11 (Streets, 469–612; Dallimore & Jackson, 446).

Pinworms — *see* **Parasitic Worms**

PIPER Linn. (*Piperaceae*)

A very large genus of shrubs, rarely herbs and trees, found throughout the tropical and sub-tropical regions of the world. About 30 species have been recorded in India, of which *P. nigrum*, the Black Pepper and *P. betle*, the *Pan* or Betel are widely cultivated.

A large number of species of this genus have been recorded as occurring wild in various tropical and sub-tropical parts of India. Some of them are reported to be used as substitutes or adulterants of the cultivated species like *P. nigrum* and *P. betle*. Their correct identification and specific delimitation are still confused and as stated by Hooker (in Fl. Br. Ind., V, 79), only a critical study of the plants "on the spot, with a view to matching the sexes, and flowering with fruiting specimens and observing the transition from young to old foliage and the effects of locality and climate on the characters of each species" will clarify their position. It is not improbable that some of

them, if selected and propagated, may prove better than some of the cultivated species. Chemical composition and characteristics of their fruits, leaves and shoots are yet unknown. It has been stated that while man adopted *P. nigrum* as pepper, he could have taken into use some other species also, which are more pungent. Similarly, the fruits of many species are used as long pepper, though their intrinsic properties are not fully known (De Candolle, *Candollea*, 1922–24, **1**, 65; Barber, *Agric. J. India*, 1906, **1**, 163; Burkill, II, 1736).

P. betle Linn. BETEL

D.E.P., VI(1), 247; C.P., 891; Fl. Br. Ind., V, 85; Quisumbing, *Philipp. J. Sci.*, 1930, **43**, 85, Text Fig. 41 & 42.

SANS.—*Nagavalli, tambula*; HINDI—*Pan, tambuli*; BENG.—*Pan*; MAR. *Pan, videchapana*; GUJ.—*Nagurvel, pan*; TEL. *Tamalapaku, nagavalli*; TAM. *Vettilai*; KAN.—*Vilayadele*; MAL. -*Vettila*.

A perennial dioecious creeper probably native of Malaysia, cultivated in India for its leaves used for chewing. Stems semi-woody, climbing by short, adventitious roots; leaves 5–20 cm. long, broadly ovate, slightly cordate and often unequal at the base, shortly acuminate, acute, entire, with often an undulate margin, glabrous, yellowish or bright green, shining on both sides; petiole stout, 2.0–2.5 cm. long; male spikes dense, cylindrical; female spikes 2.5–5.0 cm. long, pendulous; fruits rarely produced, often sunk in the fleshy spike, forming nodule-like structures.

The cultivated betel in India is usually the male plant selected from certain races and consequently does not fruit. Several types are grown in different parts of India showing variation in size, shape and colour of the leaves, their taste and aroma. So far no botanical study has been made of the varieties or types found in India. In Philippines, three varieties are described based on leaf shape and pubescence. In Indonesia and Malaysia, several races are known, some with clove-like flavour and others with red coloured veins and petioles. In Malaysia and Indonesia, many of them bear flowers and fruits freely. Environmental conditions are to some extent responsible for these variations. Leaves grown under more favourable conditions are larger in size and less pungent, while under less favourable conditions they become smaller and more pungent. Table 1 summarizes the names and characteristics of the different betel types grown in various areas in India (Burkill, II, 1738; Quisumbing, *Philipp. J. Sci.*, 1930, **43**, 85).

CULTIVATION

Cultivation of betel vine is highly specialized and is carried out with intensive care, regarding preparation of land, choice of varieties, mode of propagation, aftercare in manuring and irrigation, pest and disease control and harvesting and marketing. Consequently it is mostly confined to small holdings, distributed in almost all States in India, except in the dry north-western parts. Approximately 26,000 hectares are reported to be under this crop, Mysore, West Bengal and Madras each having nearly 4,000 hectares. The other important States are: Maharashtra, Kerala, Andhra Pradesh, Madhya Pradesh, Bihar, Uttar Pradesh and Assam. No detailed data are available regarding the acreage in different States. Some of the important districts reported to be cultivating betel are: Belgaum, Dharwar, Mysore, South and North Kanara in Mysore; Madurai, Salem, Coimbatore, Thanjavur and Chingleput in Madras; Thana (Bassein), Satara, Poona, Jalgaon, Kolhapur and Amraoti in Maharashtra; Trivandrum, Alleppey, Kottayam and Trichur in Kerala; Cuddapah, Guntur, Krishna, East and West Godavari, Vishakhapatnam, Srikakulum, Adilabad, Hyderabad and Mahbubnagar in Andhra Pradesh; and Gwalior, Chhatarpur and Durg (Chhuikhadan) in Madhya Pradesh and some districts of Assam [Chaugule, *Farm Bull.*, No. 57, 1960; Rao & Madhavachari, *Indian Fmg, N.S.*, 1966–67, **16**(7), 41].

Climate—The betel vine thrives best under tropical forest conditions having a cool shade, considerable humidity and a good supply of soil moisture. It flourishes in areas with a rainfall of 225–475 cm. It is grown up to an altitude of about 900 m. in the western ghats. The south-western coastal region of Kerala, North Kanara in Mysore, Bassein tract of Maharashtra and the north-eastern hilly regions of Assam provide these conditions and in these areas the betel vine is grown in the shade of trees or in established arecanut or coconut gardens, without any elaborate arrangements. In all other areas, particularly in the interior regions of Deccan and South India and parts of Uttar Pradesh, Bihar, West Bengal and Madhya Pradesh, it is grown under artificially created conditions, simulating natural environment.

Betel vine cultivation needs elaborate preliminary preparations, particularly when cultivated in areas where prevailing climatic conditions are not favourable for its growth, such as extremes of temperature, with hot and dry winds in summer as in parts of Madhya Pradesh, Uttar Pradesh and Rajasthan, and

TABLE 1—CHARACTERISTICS OF SOME TYPES OF P. BETLE GROWN IN INDIA*

Type	Characteristics	State or region where reported
Ambadi	Leaves narrow and long, light green with a camphor-like aroma; resembles Karpurakodi of Madras	Mysore (N. Kanara district)
Bangla (Bhubna)	Leaves thick with short tips; pungent	Originally from Bengal. Uttar Pradesh, Maharashtra, West Bengal, Madhya Pradesh
Bilahari	Leaves tender; low yielding type but fetches good price	Madhya Pradesh
Chennur	Leaves light green to yellowish, not very pungent	Madras
Chittukodi	Leaves small in size, velvety to touch; taste agreeable being neither insipid nor pungent	Madras (Sholavandan and Madurai)
Desavari	Leaves thin with long tips and pinkish veins; least fibrous	Andhra Pradesh (Hyderabad district), Uttar Pradesh
Gangeri	Leaves dark green, with pinkish veins on the lower side, tasty	Maharashtra (Sangli and Islampur area)
Kaker	Leaves long with thin veins, mediocre in taste; not of high quality	Uttar Pradesh
Kali	Leaves dark in colour and thick; pungent; wilt-resistant	Maharashtra (Nagpur, Ranitele and Poona area)
Kallasakodi	Leaves broad and tapering to the tip; dark green, coarse; pungent but leaves from older crop are finer and less pungent	Madras
Kammar	Leaves deep green, broad and coarse; aromatic	Madras (Poonamalle tract of Chingleput district and also in Vellore and Coimbatore district)
Kanigale	Leaves small and narrow having a bland taste	Mysore
Kapoori	Leaves medium thick, pungent; not of high quality	Uttar Pradesh
Karapaku	Leaves dark green, pungent	Madras
Kariballi	Leaves deep green, medium-sized, coarse in texture, pungent with good keeping quality	Mysore
Karpurakodi	Leaves light green to greenish yellow in colour, linear with camphor-like smell	Throughout Madras State, Maharashtra
Kootakodi	An improved type with broad leaves, good yielder	Kerala (Palghat district)
Kuljedu	Leaves light green, spreading, not very pungent	Madras
Kumbalaballi	Leaves very large, dark green in colour, somewhat pungent; low yielder with moderate keeping quality	Mysore
Kurhe	Leaves delicate; high yielder	Maharashtra (Poona area)
Maghai	Leaves smallest among all types, non-fibrous and very tasty, of high quality	Uttar Pradesh, West Bengal; originally from Gaya, Bihar
Mahoba	Leaves large and thick, but with very little fibre; slightly pungent when tender, less so when mature	Uttar Pradesh
Nabkar	Leaves long and tapering; high yielder but fetches average prices	Maharashtra (Bassein area)
Nadankodi	Leaves small, soft	Kerala (Calicut district)
Nagaballi	Leaves small, shaped like the hood of a cobra; low yielder	Mysore
Pandhari	Leaves pale yellow in colour	Maharashtra (Sangli and Islampur area)
Parua	Leaves large, cordate and light green	Assam
Puathi	Leaves large, cordate and light green in colour; stem slightly reddish	Assam
Pudukodi	Leaves broad and coarse with good keeping quality	Kerala (Calicut district)
Ravesi	Leaves medium-sized, light green, not very pungent	Madras (Poonamalle tract of Chingleput district)
Sanchi or Chandana	Leaves longer than broad, dark green in colour with fine, sweet flavour	Assam
Sathyavaram	Leaves light green, spreading, pungent	Madras
Semha	Leaves thick with prominent veins	Uttar Pradesh
Tellaku	Leaves light green, not very pungent	Madras
Vattakodi	Leaves big in size, more circular in shape than other types	Madras

* Changule, *Farm Bull.*, No. 57, 1960, 8-12; Yegna Narayan Aiyer, 529; Iruthayaraj, *Madras agric. J.*, 1960, **47**, 463; Krishnan & Kantiraj, ibid., 1941, **29**, 12; Choudhari, ibid., 1945, **33**, 49; Nikam & Mahadik, *Indian Fmg, N.S.*, 1958–59, **8**(4), 8; Malelu *et al.*, *Poona agric. Coll. Mag.*, 1951–52, **42**, 137; Chowdhury, *Indian Fmg*, 1944, **5**, 122; Lavania & Srivastava, *Agric. & Anim. Husb. Uttar Pradesh*, 1955–56, **6**(10), 13; Mehta, *Gardening*, 1956–59, **1**(3), 11; Information from Director of Agric., Madras, and Agronomist, Dep. of Agric., Maharashtra.

severe cold and frost in winter. In these areas, the plots are protected on the sides and tops by raising a live hedge or by constructing a mud or stone wall all round, covered over with thatch. For purposes of live hedge, quick growing plants are cultivated while for the covering, the thatch is made up of bamboo or other materials locally available. The thatch is so made as to facilitate entry of filtered sunshine, at least during part of the day. Besides, shade is also provided by planting some quick growing trees in between the rows.

The ultimate aim of all these measures is to protect the crop from adverse weather conditions and to afford a humid, hot atmosphere suitable for its growth (Chaugule, loc. cit.; Yegna Narayan Aiyer, 521).

Soil—The best soil for betel cultivation is clayey loam which is friable, rich in organic matter, and which has good drainage. Red loams, both light and heavy, with good depth are also favoured. When the soil is light and loamy, suitable manuring and addition of tank silt precedes cultivation. Where the soil is coarse or stony, large pits are dug and these are filled with suitable soil before planting (Iruthayaraj, *Madras agric. J.*, 1960, **47**, 463; Yegna Narayan Aiyer, 521; Chowdhury, *Indian Fmg*, 1944, **5**, 122).

Preparation of land—In the hilly areas of Assam and Kerala and in some parts of Mysore, where betel vine is grown under relatively natural conditions as a mixed crop in arecanut or coconut plantations, no special selection or preparation of land is made, apart from what has been done for the main crop. In these areas, pits of various dimensions (60–120 cm. in diam. and 30–60 cm. in depth) are dug at the base of the supporting trees and they are filled up with top soil along with 0.5–2.0 kg. of wood-ash or leaf-mould. In the plains, however, the land is ploughed or dug out and harrowed to obtain a fine tilth. Considerable efforts are made to adopt a suitable layout, since betel vine is sensitive to soil and climatic conditions, and needs proper maintenance of moisture, soil aeration and sufficient humidity. Where betel vines are cultivated as a mixed crop in arecanut plantations, drainage channels are made between every two, three or four rows of the arecanut trees depending upon the soil; in some areas lengthwise ditches are crossed by a number of cross drains also. In some places betel vines are grown on somewhat elevated beds, sometimes as high as 120 cm., alternating with strips of narrow trenches, where water is kept flowing or stored in pits (Yegna Narayan Aiyer, 525; Chaugule, loc. cit.).

I.C.A.R., New Delhi

FIG. 31—PIPER BETLE—PLANTATION UNDER SHADE

Betel is a climber and needs support for its growth. In coconut and arecanut plantations, the support is provided by these trees, while in other areas support is provided by growing some quick growing straight stemmed plants like *Sesbania grandiflora* Pers., *S. sesban* Merrill, *Moringa oleifera*, *Erythrina variegata* var. *orientalis*, etc. Sometimes bamboo, wooden or stone supports are used (Iruthayaraj, loc. cit.; Chaugule, loc. cit.).

Propagation—Betel vine is propagated only vegetatively by cuttings taken from healthy vines at least two years old. These are obtained from vines of the previous year's growth, trimmed into sections of 30–45 cm. length. Each cutting contains 3 to 5 nodes and is planted in such a manner that 2 nodes are buried in the soil and one or more nodes are above ground and pointing towards the standards, on to which they will eventually be trained. In some places it is the practice to raise a nursery of root cuttings and then transplant them in their permanent places. For this purpose, cuttings are planted closely about 10 cm. apart in well prepared and shaded nurseries [Yegna Narayan Aiyer, 524; Rao & Madhavachari, *Indian Fmg, N.S.*, 1966–67, **16**(7), 41].

Planting season—The planting season varies in the different tracts depending on temperature and rainfall, and also whether dead or live supports have been used. In plantations of coconut and arecanut or where dead supports are used, planting is done early in the season; where live supports are used, time is allowed for the latter to establish and develop sufficient shade and support for the vines. Based on these considerations mainly, planting starts immediately after the onset of the monsoon in May–June in Kerala, North Kanara, some parts of Mysore and in Assam. In Madras, planting is done in June–July or September–October, the latter season being preferred. In the southern districts of Maharashtra, Andhra Pradesh and some districts of Mysore, planting is delayed till about August, September or even October, since live supports are used. In some parts of Mysore and in Bassein, betel vine is a secondary crop grown after rice and hence planting is delayed up to October or even beyond (Chaugule, loc. cit.; Ambekar, *Bull. Dep. Agric., Bombay*, No. 146, 1926, 93; Rao & Madhavachari, loc. cit.).

Before planting, the beds are first irrigated. In areas like Bassein, where the wilt disease is common, the beds are irrigated with a small dose of copper sulphate kept in a basket in the irrigation channel. The setts establish in about 3 weeks' time and the first leaf is put forth in about a month. Where the vines are trained on live supports, the latter are thinned and pruned as required, to ensure good shade for the betel vines. When the setts begin to sprout and creep along, they are tied to the support at intervals of 15.0–22.5 cm. The vines strike roots when they come into contact with the standard and establish themselves firmly. Weeding and stirring of the soil is done as and when needed.

When the vines reach a height of about 3 m. they not only lose their vitality, but also become difficult to harvest. They are often rejuvenated by "lowering" them, a process in which the vines are untied from their supports and their lower portion coiled and buried in the soil, leaving free only a few nodes at the growing end. This results in a number of tillers springing up from the base and the vine becoming more vigorous. Lowering of the vines is done once in the first year, and once or twice in the second and third year (Chaugule, loc. cit.; Iruthayaraj, loc. cit.).

Manuring—In general, betel vine crop is given heavy doses of manures ranging from 25 to 100 tonnes per hectare in a year. Generally organic manures like farmyard manure, sheep manure and tank or river silt are used. Next in importance are oil cakes; other organic manures like fish manure and tannery refuse are also used where available. In Kerala and West Bengal, a little ammonium sulphate is applied along with oil cake. Bulky organic manures are considered good for leaves of superior quality. But in certain tracts of Uttar Pradesh, these manures are avoided as they may carry disease-producing fungal spores. In parts of Andhra Pradesh, Maharashtra, Mysore and Madras, farmyard manure, especially sheep manure is highly valued. In parts of Madras, cattle manure and horse dung are usually applied; sometimes tannery refuse is also used. In Coimbatore area, leaves of *Calotropis* sp. are applied at the rate of 10–15 cartloads/ha. Wild indigo leaves are also used, since they are supposed to improve leaf colour. In Maharashtra, castor cake is preferred as it is believed to prevent white ant attack, while in Bassein raw or dry fish is usually applied either alone or mixed with castor cake. In Madhya Pradesh, linseed, til, castor or neem cakes are used, whereas in Assam, mustard cake is considered to be the most suitable. In Assam, a liquid manure of cowdung is used to accelerate rooting. In West Bengal, dried, pulverized pond-mud, powdered cowdung and powdered oil cakes are used [Chaugule, loc. cit.; Iruthayaraj, loc. cit.; Rao & Madhavachari,

loc. cit.; Nikam & Mahadik, *Indian Fmg, N.S.*, 1958–59, **8**(4), 8; Chowdhury, loc. cit.].

Intercropping—In many areas along with betel vine other crops are grown as intercrops. In Madras, Mysore, Andhra Pradesh, Maharashtra and western districts of Madhya Pradesh, banana suckers are planted in betel vine gardens, either for obtaining the fibre to tie the vines or for the leaves and fibre used as packing material. In the northern districts of Madhya Pradesh, *Piper longum* is often intercropped with betel vine. In this area, in addition, *Basella rubra*, *Cephalandra indica*, *Trichosanthus* sp., *Zingiber officinale*, *Musa×paradisiaca*, *Colocasia antiquorum*, *Capsicum frutescens*, etc., are raised as catch crops. In Uttar Pradesh, some emphasis is given to the intercropping of yam and other vegetables with betel vine. In West Bengal, gourds and pumpkins are grown round the garden to give additional shelter and as a source of subsidiary income [Yegna Narayan Aiyer, 527; Iruthayaraj, loc. cit.; *Bull. Indian Cocon. Comm.*, 1955–56, **9**(2), 54; Rao & Madhavachari, loc. cit.].

Diseases and Pests—Betel vine is subject to attack by various diseases and pests. The most important among them are foot rot, wilt, leaf spot and powdery mildew among diseases, and bugs, aphids and mites among insect pests.

Foot rot is caused by the fungus *Phytophthora parasitica* Dastur var. *piperina* Dastur which lives in the soil and attacks the roots, stem and leaves. It produces a large number of spores at low temperatures, under moist conditions. These spores are carried from vine to vine through water. It occurs in a very virulent form and if not controlled, causes widespread damage and even total destruction of the betel vine plantations. The first sign of the disease is the yellowing of the lowermost leaves followed by drooping. The topmost leaves also turn dark and droop down. The leaves fall at the slightest touch. The roots also start rotting, followed by the drying up of the entire vine. Application of a monthly dose of Bordeaux mixture throughout the crop period is recommended as a control measure for the disease. Perenox is now being increasingly utilized instead of Bordeaux mixture in controlling the disease [Dastur, *Proc. Indian Acad. Sci.*, 1935, **1B**, 778; Malelu *et al.*, *Poona agric. Coll. Mag.*, 1951–52, **42**, 137; Narasimhan & Ramalingam, *Indian Fmg, N.S.*, 1967–68, **17**(2), 29].

Wilt is caused by *Sclerotium rolfsii* Sacc. In this the stem turns dark, the leaves droop and finally the plant withers and dies. The disease can be controlled by deep ploughing, green manuring, applying organic and inorganic manures and growing other crops for a few years. Formalin, diluted to 1:20 to 1:50, applied to the soil reduces losses due to this disease [Nikam *et al.*, *Indian Fmg, N.S.*, 1958–59, **8**(5), 11; Chowdhury, *Proc. Indian Acad. Sci.*, 1945, **22B**, 179; 1948, **28B**, 227; Mundkur, 231].

Powdery mildew is caused by *Oidium piperis*. The disease is characterized by the formation of circular greyish white powdery patches first on the lower surface of the leaves and then on both sides. This is followed by the yellowing of the leaves and their becoming brittle and finally falling off. The growing shoots are also affected and in severe cases the whole crop may be destroyed. Application of finely powdered sulphur once or twice acts as a preventive measure in controlling the disease (Malelu *et al.*, loc. cit.).

Leaf spot is caused by a *Gloeosporium* identified as the conidial stage of *Glomerella cingulata* (Stonem.) Spauld. & Schrenk. Brown or black spots with perceptible concentric rings appear on the leaves. These may extend to the entire leaf and also the stem which starts rotting downwards. Treatment with Bordeaux mixture or Perenox prevents the spread of the disease to the stems. A leaf spot caused by *Curvularia lunata* Boedijn and another by a bacterium are also known. When treated with chemicals the leaves should not be used for at least 15 days and even after this period they should be washed before use (Chowdhury, *Proc. Indian Acad. Sci.*, 1945, **22B**, 188; Chaugule, loc. cit.; Bhattacharya, *Proc. Indian Sci. Congr.*, 1961, pt III, 495; Raghunathan, *Trop. Agriculturist*, 1926, **67**, 242).

Betel vine is also subject to anthracnose caused by *Glomerella cingulata* (Stonem.) Spauld. & Schrenk. and *Colletotrichum piperis* Petch. Round or oval dark brown lesions appear on the stems of the vines and infected stems collapse and ultimately die. The affected vines should be destroyed by burning. Bordeaux mixture, Perenox or Cupravit can be used to control the disease (*Indian J. agric. Sci.*, 1950, **20**, 107; Nikam *et al.*, loc. cit.).

Betel vine is infested by insects, particularly betel vine bugs, mealy bugs, aphids, mites, etc. Betel vine bugs (*Disphinctus* spp.) cause serious damage in parts of Andhra Pradesh, Madhya Pradesh, Madras, Mysore, Orissa and Uttar Pradesh. Dusting with Pyrodust or spraying with 0.1 per cent DDT is recommended for control. Similarly, for mealy bugs

(*Ferrisiana virgata* Ckll., *Lepidosaphes* and *Pseudococcus* spp.), spraying with 0.06 per cent Malathion is useful. Both in the nymphal and adult stages, the bugs suck out the sap of the leaves and render them unfit for consumption [*Mem. Dep. Agric. Madras*, No. 36, 1954, 933; Crop pests and how to fight them, 125; *Plant Prot. Bull., New Delhi*, 1959, **11**(1–4), 32].

Aphids occur in groups on the underside of the leaves and both the nymphs and the adults suck the juice of the leaves. Follidol spray is an effective control measure. Mites cause great damage in the betel vine gardens by sapping the leaves. The leaves also show a blackish appearance, due to deposition of the excreta of the insects. The pest can be controlled by lime-sulphur wash (Nikam *et al.*, loc. cit.).

Harvesting and Yield—Usually, betel vine crops last for three years but in some areas they are known to last up to 12 years. Under favourable conditions and good cultivation, the vines grow fast and produce leaves of consumable size quite early. Harvesting starts in about 6 months after planting in some areas of Madras, Maharashtra, Kerala and Andhra Pradesh, where the life of the crop is short; in other places it may vary from 1 to 3 years. Each vine is picked three, four or even five times in a year, but the pickings are so arranged that all the vines are not picked at the same time. Further, two types of pickings are practised: in one all but the youngest leaves are picked out and in the other only 2 or 3 leaves are picked; while the former practice gives a large number of leaves, it weakens the vine and the annual pickings become less. In picking, the leaves are cut with the petioles clean and for this an artificial thumb-nail made of iron is often used (Yegna Narayan Aiyer, 528; Chaugule, loc. cit.; Rao & Madhavachari, loc. cit.).

The yield of betel vine varies considerably from place to place. As a rule, the yield is less in the first year but gradually increases till the maximum is obtained in the middle period of its life. The yield wanes towards the end. In West Bengal, the yield is reported to be 20 million leaves per hectare per year. In Bassein, Maharashtra, the yield in the first year is about 3.7 million leaves per hectare, rising to 15 millions in the second year. In Mysore, betel gardens either grown independently or in conjunction with arecanut are reported to yield 1.3–3.0 million leaves per hectare. The yield in Assam, Andhra Pradesh, Madras, Maharashtra, and Kerala ranges from 7.5 to 18.0 million leaves per hectare per year (Yegna Narayan Aiyer, 528; D'Souza, *Poona agric. Coll. Mag.*, 1955-56, **46**, 337; Iruthayaraj, loc. cit.).

Bleaching—While fresh leaves are generally used for chewing, in some areas leaves subjected to a process of bleaching or blanching are preferred. Bleached betel leaves normally fetch a higher price as they are believed to possess some improved qualities. Bleaching of leaves on a commercial scale is carried out in parts of North India, particularly at Varanasi, Gorakhpur, Ramtek (near Nagpur), and Poona and its neighbourhood: it is also reported to be done in parts of Vizianagaram (Andhra Pradesh). The bleaching process consists in moistening the leaves and allowing them to stand in a warm, ventilated place in the absence of sunlight. Leaves for bleaching should not be very tender and are taken from older vines with well developed leaves. They have a dark green colour with a prominent midrib and a rather rough stalk and surface. In commercial bleaching process, lots of 25–35 kg. of leaves (comprising 16,000–20,000 in number) are bleached at a time. The leaves after removal of the stalks are packed together in a basket (60–75 cm. in diam., 30–45 cm. high) lined with matting, or in galvanized iron pots with plantain leaves spread on the sides and the bottom. Betel leaves are arranged almost vertically in layers, forming 3 or 4 circles of leaves in each layer. A vertical empty space is left out in the centre for aeration. The leaves after arranging are sprinkled with the required quantity of water (2.5–7.5 kg., depending upon the season) and covered with a moist gunny bag; if the amount of water added is excessive, the leaves become dark and rot quickly without bleaching well, whereas if it is too inadequate, bleaching will be uneven and the leaves are apt to dry. During bleaching, the leaves turn gradually yellowish white. After 5 or 6 days, they are taken out of the containers, bleached and rotten leaves separated, and the rest rearranged in the container. The examination of the leaves is repeated at intervals, and the whole process normally takes 10–15 days in summer and 15–20 days in cold seasons. Roughly half of the leaves get bleached. Leaves becoming turmeric yellow instead of yellowish white and those bearing red or brown patches are discarded. Finally, bleached leaves are dried to remove surface moisture and packed for market.

In some areas, a modified process is employed particularly for bleaching in winter. Instead of storing the leaves in a room for bleaching, the baskets containing the leaves are kept in small pits 160 cm. ×

100 cm. × 100 cm. plastered with mud and pre-heated by burning cowdung. This process takes about 10–15 days. Bleaching can be effected more rapidly (in *c.* 6 days) and uniformly with less rotting losses at temperatures of 29–33°. Oxidation plays a prominent role in the bleaching of betel leaves. Presence of slight acidity during bleaching is necessary, while even traces of alkalinity lead to almost a complete destruction of the leaf [Yegna Narayan Aiyer, 531 : Mann *et al., Mem. Dep. Agric. India, Chem.*, 1913–14, **3,** 17 ; Mann & Patwardhan, ibid., 1914–16, **4,** 281 ; Chaugule, loc. cit. ; Dastane *et al., Indian Fmg, N.S.*, 1957–58, **7**(10), 10 ; Lavania & Srivastava, *Agric. Anim. Husb., Uttar Pradesh,* 1955–56, **6**(10), 13].

Grading and Marketing—The picked leaves are washed, cleaned, counted and sorted into different grades, according to size, colour, texture and maturity on which their chewing quality depends. Grading is done in different ways in different areas, sometimes depending on their position on the vine, their maturity and place of production. In some parts of Deccan, the leaves gathered from the branches are called *Hatvan* and are considered the best ; those at the nodes on the main stem are of medium quality and are known as *Angwan*. In some areas, the leaves are classified into three grades, *Babla* (large sized), *Adke* (medium sized) and *Modwan* (small sized). In Madhya Pradesh, they are termed *Bade pan* (big leaved) and *Khitti* or *Natwan* (small leaved). On the basis of their colour and maturity on the vines, the new leaves are called *Navati*, the second flush as *Parati*, and the third flush *Terti ;* those kept on the vines to mature for a long time till good market conditions are available are called *Junwan*. In Uttar Pradesh, the commercial grades recognized, mainly on basis of place of origin are: *Desi* (local), *Maghai* (Bihar), *Bangla* (Bengal), *Jagannathi* (Orissa) and

FIG. 32—PIPER BETLE—LEAVES OF DIFFERENT TYPES

Kapoori (Madras). In Andhra Pradesh, the leaves are graded into *Kalli* (first sort), *Papada* (second sort) and *Kalagotha* (medium sort). *Kalli* leaves are gathered from lateral shoots and are mostly consumed locally or in nearby centres. *Papada* comprises the bigger leaves exported to distant places. In Salem district (Madras), the leaves are graded into *Mar* and *Chakkai* leaves, the former comprising tender leaves from laterals and the latter the mature leaves from the main stem (Chaugule, loc. cit.; Iruthayaraj, loc. cit.; Rao & Madhavachari, loc. cit.).

In Madras, the plucked leaves after washing, cleaning and counting are arranged in baskets before they are sent out for sale. The unit of sale in Chingleput district is one *Kavili* of 100 leaves, whereas in Coimbatore one *Kavili* consists of 200 leaves. In Coimbatore, the unit of packing is one *Palagai* of 2,000 leaves. In Andhra Pradesh and Maharashtra, unit of packing is a basket containing 3,000 to 6,000 leaves depending upon leaf size. In Kerala, the harvested leaves are graded according to size and maturity, and arranged in 100-leaf bundles in broad baskets, having a lining of plantain leaves at the bottom. Water is sprinkled on the leaves and the basket covered with plantain leaves and tied up. In Madhya Pradesh, the leaves are generally packed in bamboo baskets specially made for the purpose. They are first made into small bundles of 100 leaves each. The bundles are arranged in circular rows in the baskets. The rows are arranged from the periphery of the baskets and closed towards the centre. Thus rows upon rows are arranged. For protection during transit, a layer of *Palas* (*Butea monosperma*) leaves is interposed between the *pan* layers and the walls of the basket [Iruthayaraj, loc. cit.; Malelu *et al.*, loc. cit.; Chowdhari, *Madras agric. J.*, 1945, **33**(3 & 4), 49; Krishnan & Kantiraj, ibid., 1941, **29**(1), 12; *Bull. Indian Cocon. Comm.*, 1955–56, **9**(2), 54].

Betel leaves are consumed or marketed as early as possible after harvesting. Trials have shown that they can be stored in cold storage at a temperature of 5.5–7.0° and an R.H. of 85–90 per cent, the storage life of unpacked leaves extending up to 8 days. For better storage, packing the leaves in polyethylene bags, with or without respiration vents is advocated, the mode of packing depending upon the temperature of storage (*Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 194; Iyengar *et al.*, ibid., 1955–56, **5**, 307).

Small quantities of betel leaves are exported to some countries outside India. Table 2 gives details of exports of betel leaves during 1962–67.

TABLE 2—EXPORTS OF BETEL LEAVES FROM INDIA
(Qty in thousand kg. and Val. in thousand Rs.)

Countries	1962–63	1963–64	1964–65	1965–66	1966–67
U.K.	16.2	28.9	67.8	38.9	6.6
Kenya	33.7	32.6	53.9	30.6	13.5
Aden	19.1	24.3	38.2	27.1	3.1
Pakistan, East	12.3	2.0	6.9	(a)	1.2
Bahrein Islands	7.8	8.3	7.3	4.3	2.4
Kuwait	7.1	11.3	12.7	9.8	3.0
Nepal	1.4	(a)	(a)	54.6	10.8
Others	19.1	21.9	28.4	29.7	12.0
TOTAL QTY	116.7	129.3	215.2	195.3	52.6
TOTAL VAL.	199.8	272.6	411.4	539.0	150.2

(a) below 1,000 kg.

UTILIZATION AND COMPOSITION

Utilization—Betel leaves have a strong pungent aromatic flavour and are widely used as a masticatory. Generally, mature or overmature leaves which have ceased growing but not yet become brittle are used for chewing. The basic preparation for chewing purposes consists of betel leaf smeared with hydrated lime and catechu to which scrapings of arecanut are added; flavourings such as coconut shavings, clove, cardamom, fennel, powdered liquorice, nutmeg and also tobacco are used according to one's taste. In some places prepared pan is covered with silver or gold leaf. A beverage called *pan-supari* nectar, has been developed by the Central Food Technological Research Institute, Mysore, and is said to be a good source of calcium [Gowda, *Bot. Mus. Leafl. Harv.*, 1951, **14**(8), 181; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 2].

Chewing of betel leaves with various adjuncts is an ancient practice in India and other countries of East Asia. As a masticatory, it is credited with many properties: it is aromatic, digestive, stimulant and carminative. Medicinally it is useful in catarrhal and pulmonary affections; it is also used for poultices (Burkill, II, 1740; Kirt. & Basu, III, 2132; Chopra, 1958, 371; Quisumbing, 213).

Studies on the physiological effects of chewing betel leaves have shown that the initial effects of chewing of betel with arecanut and other adjuncts are the excitation of the salivary glands and the irritation of the mucous membrane of the mouth. The red colouration produced is due to a pigment in the arecanut, which manifests itself under the action of alkali in

lime and catechu. A mild degree of stimulation is produced, resulting in a sensation of warmth and well-being, besides imparting a pleasant odour. The active principle responsible for the stimulating effects upon the central nervous system is the alkaloid, arecoline present in arecanut ; lime helps in liberation of the alkaloid. The essential oil in the leaf is reported to enhance the effects of arecanut and to act synergistically upon the central nervous system (Chopra, 1958, 373–74).

Excessive indulgence in chewing for long periods is liable to produce dental caries, pyorrhoea alveolaris, oral sepsis, dyspepsia, palpitation, neurosis and slow cerebration. Chewing is reported to lead sometimes to carcinomatous growths in the mouth, but it is considered that the use of tobacco with pan may be responsible for it ; this question remains to be conclusively proved (Chopra, 1958, 375–77 ; Chopra & Chopra, 84–85 ; Eisen, *Cancer Res.*, 1946, **6**, 139 ; *Food Sci.*, 1960, **9**, 137).

Betel chewing is considered as a good and cheap source of dietary calcium. The calcium ingested is reported to be well absorbed by the system. However, there are differences of opinion as to the source from which calcium is derived and its ingestion by the system. It has been stated that the availability of calcium from the leaf is poor, since nearly 94 per cent of the calcium present is bound up with oxalic acid and there is a considerable amount of free oxalic acid in the leaf, which interferes with the calcium utilization from other foods (Basu *et al.*, *Indian J. med. Res.*, 1942, **30**, 309 ; Iyengar & Rau, *Ann. Biochem.*, 1952, **12**, 41).

Composition—Analysis of a sample of fresh leaves gave the following values: moisture, 85.4 ; protein, 3.1 ; fat, 0.8 ; carbohydrates, 6.1 ; fibre, 2.3 ; and mineral matter, 2.3% ; calcium, 230 mg. ; phosphorus, 40 mg. ; iron, 7 mg. ; ionisable iron, 3.5 mg. ; carotene (as vitamin A), 9,600 I.U. ; thiamine, 70 μg. ; riboflavin, 30 μg. ; nicotinic acid, 0.7 mg. ; and vitamin C, 5 mg./100 g. Betel leaves contain 3.4 μg./100 g. of iodine. They have a high content of potassium nitrate (0.26–0.42%), the amount depending upon the position of the leaf on the vine. The important constituents which determine the value of the leaf for chewing are the essential oil and the sugars. Betel leaves from Bombay contained reducing sugars (as glucose), 1.4–3.2 ; non-reducing sugars (as sucrose), 0.6–2.5 ; total sugars, 2.4–5.6 ; starch, 1.0–1.2 ; essential oil, 0.8–1.8 ; and tannin, 1.0–1.3% (Nutritive Value of Indian Foods, 83, 118, 141 ; Iodine Content of Foods, 122; Mann & Patwardhan, *Mem. Dep. Agric. India, Chem.*, 1914–16, **4**, 281 ; Mann *et al.*, ibid., 1913–14, **3**, 17).

Properly bleached betel leaves are of a sunflower yellow to whitish yellow colour, very soft, tender, clear of any stains, very bright and become brighter on keeping. Brittle or too highly bleached leaves are not preferred. During bleaching, there is an increase in the essential oil content, acidity and reducing sugars and a decrease in non-reducing sugars, starch and diastase. Analysis of samples of fresh and bleached leaves from Poona showed, respectively: non-reducing sugars, 1.30, 0.29 ; reducing sugars, 0.43, 0.83 ; starch, 3.10, 1.44 ; tannin, 2.05, 1.89 ; ether extr., 15.7, 13.5 ; and essential oil, 1.23, 4.20% [Mann *et al.*, loc. cit. ; Mann & Patwardhan, loc. cit. ; Dastane *et al.*, *Indian Fmg, N.S.*, 1957–58, **7**(10), 10].

Leaves for chewing should contain little starch and reducing sugars but a high proportion of sucrose. Tannin and nitrate contents do not seem to influence the quality. The young leaves, not yet sufficiently mature for picking, contain more of reducing sugars and little sucrose. The sugars, starch and tannin reach a maximum until the leaves mature and then decline to a constant amount. In overmature leaves, reducing sugars account only for about one third of the total sugars. The sugars identified in betel leaves include glucose, fructose, maltose and sucrose. The average content of free reducing sugars in different types of betel leaves from West Bengal ranged from 0.38 to 1.46 per cent. The leaf juice is acidic in nature ; malic and oxalic acids have been reported. Diastase and catalase are among the enzymes present in the leaves. Alkaloids and glycosides are reported to be absent [Mann & Patwardhan, loc. cit. ; Mann *et al.*, loc. cit. ; Airan & Sheth, *J. Univ. Bombay, N.S.*, 1957–58, **26A**(42), pt 3, 1 ; Banerjee & Pain, *Sci. & Cult.*, 1936–37, **2**, 523 ; Basu *et al.*, *J. Indian chem. Soc.*, 1934, **11**, 265].

The leaves contain good amount of B vitamins (particularly nicotinic acid), ascorbic acid and carotene. The vitamin values of different Bengal types ranged as follows: carotene, 1.9 mg. ; thiamine, 10–12 μg. ; riboflavin, 1.9–3.5 μg. ; nicotinic acid, 0.63–0.89 mg. ; and ascorbic acid, 23.5–31.1 mg./100 g. In another investigation, the ascorbic acid content of different types of betel from West Bengal ranged from 4.3 to 22.5 mg./100 g. Betel leaves from Bombay contained 2.45 mg./100 g. of carotene (17.5 mg./100 g. on dry basis) [Sanyal & Sen, *Proc. Indian Sci.*

Congr., 1956, pt III, 349; Acharya & Malpoorwala, *J. Univ. Bombay, N.S.*, 1952-53, **21A**(32), pt 3, 47; Ghani & Sial, *Pakist. J. Sci.*, 1952, **4**, 153; Banerjee & Pain, loc. cit.].

The leaves contain significant amounts of all the essential amino acids except lysine, histidine and arginine which occur in traces. Large concentrations of asparagine are present, while glycine (in a combined state) and proline occur in good amounts; ornithine is present in traces. An aqueous diffusate of the bleached leaves contained the following amino acids: leucine, 18.3; phenylalanine, 14.2; alanine, 11.0; arginine, 2.4; threonine, 12.0; serine, 22.1; aspartic acid, 23.0; glutamic acid, 29.7; methionine, 13.5; valine, 3.8; tyrosine, 1.2; and γ-aminobutyric acid, 20.2 mg./100 ml. (Radhakrishnan *et al.*, *J. Indian Inst. Sci.*, 1955, **37A**, 178; Airan & Sheth, loc. cit.).

Oil of Betel—The most important factor determining the aromatic value of the leaf is the amount and particularly the nature of the essential oil present. Betel leaves from different regions vary in smell and taste. The most pungent is the *Sanchi* type, while the most mild and sweet ones are from Madras. The essential oil content of different Indian types varies from 0.7 to 2.6 per cent. The yield of oil depends upon such factors as the type, situation on the vine, time of plucking, and nature of material distilled—fresh or dry, bleached or unbleached. Leaves from the upper parts of the plant, especially on the branches contain more essential oil than those from the lower parts. The oil content increases with the maturity of the leaves but declines in over-ripe leaves. During bleaching, the oil content of the leaves increases considerably; in a particular study, it rose from 1.2 per cent in the unbleached leaf to 4.2 per cent in the bleached product (Ghani & Sial, loc. cit.; Dutt, *Indian Soap J.*, 1955–56, **21**, 275; Guenther, V, 160; Mann *et al.*, loc. cit.; Mann & Patwardhan, loc. cit.).

Oil of betel is a bright yellow to dark brown liquid possessing an aromatic, somewhat creosote-like odour resembling that of tea, and with a pungent, sharp taste. Oils from fresh leaves have a lower specific gravity and are brighter as compared to those from dried material. Characteristics of oils distilled from leaves from different places in India are given in Table 3. The oil consists of phenols and terpenes, their relative proportions varying with the origin of

TABLE 3—CHARACTERISTICS AND COMPOSITION OF OILS OF BETEL FROM DIFFERENT SOURCES IN INDIA

	Calcutta[1]	Gorakhpur[1]	Saugor[2,a]	Bombay[1]	Ramtek[1] (Bleached)
Yield, %	1.2	0.7	0.7	..	2.6
Sp. gr.	0.9408	0.9452	0.9691 (at 27°)	0.9404 (at 28°)	1.0182
n	1.5048	1.5066	1.5073 (at 27°)	1.5035	1.5088
$[\alpha]_D$	+0.9°	+1.8°	+9.3	−1.9	+2.5
Sap. val.	8.4	7.8	163.2	127.8	5.8
Sap. val. after acetylation	134.2	128.4	332.6	286.7	158.6
Acid val.	4.2	4.6	5.5	37.1	14.8
Phenol content, %	58.8	41.6	54.6	42[b]	76.8
Solubility in 80% alcohol	Soluble	Soluble	Soluble	Soluble	Soluble with slight opalescence
Composition, %					
Eugenol	42.5	26.8	40.5	..	38.5
Carvacrol	4.8	2.2	4.4	..	5.6
Chavicol	7.2	8.2	5.1	..	16.7
Allyl catechol	2.7	4.6	3.5	..	6.2
Chavibetol	1.2	nil	nil	.	9.6
Cineole	4.8	3.6	6.2	..	2.4
Estragol	7.6	14.6	7.5	..	nil
Eugenol methyl ether	8.2	15.8	..	..	4.2
p-Cymene	1.2	1.2	..	..	2.5
Caryophyllene	6.2	9.8	11.9	..	3.0
Cadinene	8.8	6.7	9.1	..	2.4
Unidentified sesquiterpenes	4.5	5.8	..	..	6.8

[1] Dutt, *Indian Soap J.*, 1955-56, **21**, 275; [2] Nigam & Purohit, *Riechstoffe u. Aromen*, 1962, **12**, 185.
[a] The oil contains also α-terpinene (2.3%) and an unidentified γ-lactone sesquiterpenene (7.5%); [b] Predominantly eugenol with some chavibetol.

the leaves. The higher the proportion of phenols in the oil, the better the quality. Bleaching of leaves is reported to increase the concentration of phenols in the oil. An isomer of eugenol named chavibetol (betel phenol ; 4-allyl-2-hydroxy-1-methoxy benzene ; $C_{10}H_{12}O_2$, m.p. 8.5°) is considered to be the characteristic constituent of betel oil : it was, however, absent in some Indian samples. Betel oils of Indian types contain eugenol as the predominant phenolic constituent (Gildemeister & Hoffmann, IV, 530 ; Mann *et al.*, loc. cit. ; Mann & Patwardhan, loc. cit. ; Dutt, loc. cit. ; Dictionary of Organic Compounds, I, 585).

Oil of betel has been used in the treatment of various respiratory catarrhs, and as a local application, either by gargle or by inhalation, in diphtheria. It has carminative properties. The oil shows a marked irritant action on the skin and mucous membrane. It produces an inflammatory reaction when injected subcutaneously or intramuscularly. In moderate doses, it appears to have antispasmodic action on involuntary muscle tissue, inhibiting excessive peristaltic movements of the intestines. It exhibits a depressant action on the central nervous system of mammals : lethal doses produce deep narcosis leading to death within a few hours (U.S.D., 1955, 1602 ; Chopra *et al.*, *Indian J. med. Res.*, 1954, **42,** 385).

The essential oil and extracts of the leaves possess activity against several Gram-positive and Gram-negative bacteria such as *Micrococcus pyogenes* var. *albus* and var. *aureus, Bacillus subtilis* and *B. megaterium, Diplococcus pneumoniae, Streptococcus pyogenes, Escherichia coli, Salmonella typhosa, Vibrio comma, Shigella dysenteriae, Proteus vulgaris, Pseudomonas solanacaerum, Sarcina lutea* and *Erwinia carotovora*. The antiseptic activity is probably due to the presence of chavicol. The essential oil and leaf extracts also showed antifungal activity against *Aspergillus niger* and *A. oryzae, Curvularia lunata* and *Fusarium oxysporum*. The oil is found to be lethal in about 5 minutes to the protozoa, *Paramoecium caudatum*, in dilutions of up to 1 : 10,000. It inhibits the growth of *Vibrio cholerae* in a dilution of 1 : 4,000, *Salmonella typhosum* and *Shigella flexneri* in 1 : 3,000, and *Escherichia coli* para A and *Micrococcus pyogenes* var. *aureus* in 1 : 2,000. Steam-distillate of the leaves showed activity against *Mycobacterium tuberculosis* in dilutions of 1 : 5,000 (Pai & Irani, *Indian med. Gaz.*, 1950, **85,** 302 ; Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49,** 799 ; Chopra *et al.*, ibid., 1954, **42,** 385 ; Bangar *et al.*, *Indian J. Pharm.*, 1966, **28,** 327 ; Lewis, 318 ; Gupta & Viswanathan, *Antibiot. & Chemother.*, 1956, **6,** 194 ; George *et al.*, *J. sci. industr. Res.*, 1947, **6B,** 42).

Betel leaves possess an anti-oxidant action ; when heated with oils and fats, especially ghee, they check the development of rancidity in them. They are effective in preserving refined groundnut, mustard, sesame, coconut and safflower oils. The anti-oxidant action of the leaves is due to the presence of phenols, particularly hydroxy-chavicol (4-allyl pyrocatechol), the effect of which is comparable to the well-known anti-oxidants like propyl gallate, NGDA and BHA. Hydroxy-chavicol is easily soluble and in the concentrations employed (up to 0.03%) does not impart any odour or taste to the oils. The ascorbic acid in the leaves probably acts as a synergist to the phenols present in them (Sethi & Aggarwal, *J. sci. industr. Res.*, 1952, **11B,** 468 ; 1956, **15B,** 34).

P. cubeba Linn. f. CUBEBS, TAILED PEPPER

D.E.P., VI(1), 257 ; C.P., 890 ; Fl. Java, I, 170.

HINDI & BENG.—*Kabab chini* ; MAR.—*Himsi mire, kababa chini, kankola* ; GUJ.—*Kababchini, tadamiri* ; TEL.—*Chalava-miriyalu, tokamiriyalu* ; TAM. & MAL.—*Val-milaku* ; KAN.—*Bala menasu*.

A liana-like climber, native of Indonesia, reported to be cultivated in India, but the fruits are largely imported (Table 4). Leaves glabrous, ovate oblong with cordate or rounded base ; fruit sub-globose, 6–8 mm. diam., somewhat apiculate, stalked. This is a very variable species cultivated mostly in Java and Sumatra. Efforts have been made to cultivate it in India, mostly in Mysore, but not or on a commercial scale. Cubebs can be easily grown by planting at the foot of the shade trees in coffee plantations. The fruits are collected when fully grown but still green, and dried in the sun when they become black and wrinkled (Nicholls & Holland, 364).

TABLE 4—IMPORTS OF CUBEBS INTO INDIA

(Qty in thousand kg. and Val. in thousand Rs.)

	Countries from which imported					
	Malaysia	Singapore	Indonesia	Others	Total Qty	Total Val.
1962–63	47.1	23.1	nil	nil	70.2	249.9
1963–64	42.7	32.1	nil	2.6	77.4	192.4
1964–65	55.9	26.2	nil	nil	82.1	171.5
1965–66	104.5	nil	0.4	nil	104.9	218.9
1966–67	17.6	35.7	2.7	0.5	56.5	142.1

The fruit is almost globular (diam., 3–6 mm.), with a slender stalk-like portion (length, up to 7 mm.) attached to its base; hence cubebs are also known as Tailed Pepper. The pericarp is dusky red to slightly brown, rarely greyish in colour. Cubebs possess a spicy, aromatic odour and a somewhat bitter and acrid taste. *Piper* species yielding fruits of similar nature are: *P. ribesioides* Wall. and *P. sumatrana* DC. which are considered possibly as large forms of *P. cubeba*. Fruits of other species of *Piper* like *P. crassipes* Korth., *P. cannum* Blume and *P. baccatum* Blume are reported to be used as substitutes or adulterants. Fruits obtained from *P. clusii* DC. and *P. guineense* DC. are also used as substitutes; they are often called False Cubebs and are obtained from Africa. Fruits of *Litsea cubeba* Pers. are also used as substitute (Burkill, II, 1737, 1742–44, 1752; Guenther, V, 149; van Steenis Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 40).

Adulteration of true cubebs with similar fruits from other *Piper* spp. can be detected by visual examination, or under the microscope, or by treatment with sulphuric acid with which the true fruits develop a bright red colour, while the adulterants give a violet or brownish colour. Trade standards require that a given lot of cubebs should contain: shrivelled and immature fruits, $\not>10$; stems, $\not>5$; foreign organic matter, $\not>2$; and acid-insoluble ash, $\not>2\%$; each 100 g. of the cubebs should yield not less than 13 ml. of volatile oil (Guenther, V, 148–50).

The most characteristic constituent of cubeb is the essential oil (Oil of Cubeb), the proportion of which varies from 5 to 20 per cent. In addition, the fruits contain resinous matter (6.4–8.5%), gum, colouring matter, fixed oil, starch and nitrogenous substances. The resinous matter is made up of several acidic and neutral substances of undetermined composition, including cubebin ($C_{20}H_{20}O_6$, m.p. 132°) having a bitter taste, cubebol and cubebic acid. The therapeutic value of the drug is said to be largely due to cubebic acid (U.S.D., 1955, 403; Guenther, V, 152; Wehmer, I, 197; Thorpe, IX, 90).

Oil of cubeb is obtained by steam distillation of the crushed fruits. The oil derived from true cubebs is a somewhat viscous liquid, light green to blue green in colour, possessing a spicy odour characteristic of the fruits and a warm, camphoraceous, slightly acrid taste. To obtain a colourless oil, the highest boiling blue fractions are separated from the main oil during distillation. In general, the oils distilled from true fruits are characterized by a pronounced laevo-rotation and a high specific gravity, whereas most oils from spurious cubebs exhibit dextro-rotation and a comparatively low specific gravity. Oils from old fruits possess a higher specific gravity than those from recently harvested ones, due probably to the presence of cubeb camphor. Table 5 gives the physico-chemical properties of cubeb oils (Guenther, V, 150–53).

Early investigations on chemical composition of the oil indicated the presence of a dipentene, a *l*-terpene (pinene or camphene), *l*-cadinene, azulene, and the so-called cubeb camphor which is probably a sesquiterpene alcohol ($C_{15}H_{26}O$, m.p. 105–06°) found especially in oils from old samples. Examination of a dextro-rotatory oil ($[\alpha]_D$, +25.6°) distilled from Mysore samples, showed the following approximate composition: *d*-sabinene, 33; *d*-Δ^1-carene and 1,4-cineole, 12; *d*-terpinen-4-ol and other terpene alcohols, 11; sesquiterpenes mainly *l*-cadinene, 14; and sesquiterpene alcohols, 17%. The dextro-rotation of this oil leads one to suspect that it was distilled from spurious fruits, but the authors claim that the cubebs used were of undoubted authenticity, though possibly slightly immature. In a more recent investigation, the oil derived from another sample was found to be laevo-rotatory ($[\alpha]_D$, −10.1°) and to contain about 50 per cent of sesquiterpene compounds including a mixture of copaene and a cadalene type sesquiterpene (7.2%), a new tricyclic sesquiterpene

TABLE 5—PHYSICO-CHEMICAL PROPERTIES OF OIL OF CUBEB

	Foreign Commercial Samples	Mysore Samples		
	(1)	(2)	(3)	(4)
Yield of oil, %	10–18	11.8	7.5	5.8
Sp. gr.[1,4]	0.915–0.930	0.9167	0.8937 (at 30°)	0.8994 (at 25°)
$[\alpha]_D$	−25° to −43°	29.9	+25.6	10.7
$n^{20°}$	1.4938–1.4981	1.4894 (at 25°)	1.4811 (at 30°)	1.4885 (at 25°)
Acid val.	up to 0.8	..	0.8	0.3
Ester val.	1.9–5.6	0.5*	5.2	15.2
Ester val. after acetylation	25–30	24.1†	54†	45.2
Solubility in 90% alcohol	up to 10 vols.	5 vols.	..	..

[1] Guenther, V, 150; [2] Rao *et al.*, *J. Indian Inst. Sci.*, 1925, **8A**, 159; [3] Rao *et al.*, *J. Soc. chem. Ind., Lond.*, 1928, **47**, 92T; [4] Razdan & Bhattacharyya, *Perfum. essent. Oil Rec.*, 1954, **45**, 181.
* Sap. val. † Sap. val. after acetylation.

(5%), a sesquiterpene alcohol probably *l*-cadinol (3%), a new sesquiterpene alcohol of the cadalene type (5%), an azulene alcohol and azulene probably S-guaiazulene (1%) (Guenther, V, 153; Rao *et al., J. Soc. chem. Ind., Lond.*, 1928, **47**, 92T; Razdan & Bhattacharyya, *Perfum. essent. Oil Rec.*, 1954, **45**, 181).

Uses—Cubebs are used as a drug and as a spice. The powdered fruits are employed in the treatment of dysentery, catarrh and as an aromatic stimulant, local irritant, antiasthmatic, diuretic, carminative and sedative, and in rheumatism. They have been used as an internal antiseptic in gonorrhoeal urethritis and as an expectorant and stimulant to the broncheal mucous membrane. The most commonly used preparation is in the form of cubeb oleoresin, which is prepared by extracting cubebs with alcohol or ether. Oil of cubeb was formerly used in the same way as the fruits, but at present, it is rarely employed medicinally except as a local remedy in the form of lozenges for the relief of various throat conditions. It is used for flavouring of bitters and cigarettes and as a condiment. It may be employed in traces for perfuming soaps (Snell & Snell, 519; U.S.D., 1955, 403; Guenther, V, 155; Poucher, I, 148).

Alcoholic extracts of cubebs showed antibacterial activity against *Micrococcus pyogenes* var. *aureus* while acetone extracts were effective as mosquito larvicides. Cubeb oil is reported to be effective against influenza virus and *Bacillus typhosus*. When taken by mouth, it is found to exert a positive, if not very strong, antiseptic effect on urine (George *et al., J. sci. industr. Res.*, 1947, **6B**, 42; Bose *et al.*, ibid., 1949, **8B**, 157; *Chem. Abstr.*, 1948, **42**, 4301; 1960, **54**, 21459; U.S.D., 1955, 403).

P. longum Linn. INDIAN LONG PEPPER

D.E.P., VI(1), 258; C.P., 891; Fl. Br. Ind., V, 78; Kirt. & Basu, III, 2128, Pl. 821A.

HINDI—*Pipal, pipli, piplamul* (root); BENG.—*Piplamor* (root); MAR.—*Pimpli*; GUJ.—*Pipli*; TEL.—*Pippuloo*; TAM.—*Tippili, pippili, sirumulam, kandan tippili* (root); KAN.—*Hippali, tippali*; MAL.—*Tippali, pippali, magadhi.*

A slender aromatic climber with perennial woody roots occurring in the hotter parts of India, from Central Himalayas to Assam, Khasi and Mikir hills, lower hills of Bengal, and evergreen forests of western ghats from Konkan to Travancore; it has been recorded also from Car Nicobar Islands. Stems creeping, jointed; young shoots downy; leaves 5–9 cm. long, 3–5 cm. wide, ovate, cordate with broad rounded lobes at base, subacute, entire, glabrous; spikes cylindrical pedunculate, male larger and slender, female 1.3–2.5 cm. long and 4–5 mm. diam.; fruits ovoid, yellowish orange, sunk in fleshy spike.

Long pepper as sold in India appears to be derived from two or three species, including one which is Indonesian. Indian Long Pepper is a product either of *P. longum* or *P. peepuloides*, while the Indonesian or Java Long Pepper imported from Malaysia is from *P. retrofractum*. The products of these species are used for the same purposes, though they vary in their effectiveness. Indian long pepper is mostly derived from the wild plants, the main sources of supply being Assam, West Bengal, Nepal and Uttar Pradesh. Small quantities are also available from evergreen forests of Kerala, West Bengal and certain parts of Andhra Pradesh. It is reported to be cultivated at low elevations in Anaimalai hills in Madras and parts of Assam, particularly in the Cherrapunji area (Atal & Ojha, *Econ. Bot.*, 1965, **19**, 157; Information from Industrial Section, Indian Museum, Calcutta).

P. longum is cultivated on a large scale in limestone soil, 450–600 m. below the Cherrapunji region which receives very heavy rains from the end of March to the middle of September and where the relative humidity is high. Long pepper is cultivated mainly by layering of mature branches or by suckers planted at the beginning of the rainy season. The vines are well manured with cowdung cake and start bearing three to four years after planting. The spikes are harvested in January, while still green and unripe, as they are most pungent at this stage. They are dried in the sun when they turn grey. The yield increases from 560 kg. per hectare in the first year to 1,680 kg. per hectare in the third. After the third year, the vines become less productive and should be replaced (Ridley, 314–15).

India imports a large quantity of long pepper from Malaysia and Singapore (Table 6). In 1966–67, the

TABLE 6—IMPORTS OF LONG PEPPER INTO INDIA
(Qty in thousand kg. and Val. in thousand Rs.)

	Countries from which imported					
	Malaysia	Singapore	Indonesia	Others	Total Qty	Total Val.
1962-63	210.8	101.6	nil	nil	312.4	864.7
1963-64	194.2	92.1	nil	nil	286.3	810.8
1964-65	179.1	85.2	0.8	7.0	272.1	1,014.0
1965-66	65.5	nil	0.6	5.0	71.1	236.9
1966-67	86.6	53.1	22.3	nil	162.0	452.8

FIG. 33—DIFFERENT TYPES OF LONG PEPPER: 1, Murshidabad (Asli); 2, Shillong (Savali); 3, Cooch Behar & Assam (Bodki); 4, Cooch Behar & Assam (Gol); 5, Purnea; 6, Central Bengal; 7, Indonesia (Piper retrofractum)

total imports amounted to 162,000 kg. valued at nearly 4.5 lakh rupees. A small quantity of long pepper is exported in some years to Afghanistan, Ceylon and Pakistan. Probably the imports are mostly of Java type from *P. retrofractum,* while exports are of *P. longum* and *P. peepuloides.*

The fruits are used as spice and also in pickles and preserves. They have a pungent pepper-like taste and produce salivation and numbness of the mouth. Since both *P. longum* and *P. retrofractum* are often passed under the common name of long pepper, some uncertainty exists as to the identity of samples on which microscopical and chemical studies have been reported. Recent work on the fruit of *P. longum* has shown the presence of the alkaloids piperine (4–5%) and piplartine (m.p. 124–25°), and two new liquid alkaloids, one of which is designated as alkaloid A. This is closely related to pellitorine producing marked salivation, numbness and a tingling sensation of mucous membranes of the mouth. Alkaloid A showed significant *in vitro* antitubercular activity against *Mycobacterium tuberculosis* H–37 Rv strain; it inhibited the growth of the bacillus in 20μg./ml. concentrations. Sesamin ($C_{20}H_{18}O_6$, m.p. 122°), dihydrostigmasterol and a new sterol, piplasterol are also present (Atal & Ojha, *Econ. Bot.*, 1965, **19**, 157; Winton & Winton, IV, 336–37; Atal *et al.*, *Indian J. Chem.*, 1966, **4**, 252; *Indian J. Pharm.*, 1966, **28**, 80; Information from Indian Council of Medical Research, New Delhi).

A sample of dried fruit of *P. longum* on steam distillation gave 0.7 per cent of an essential oil with spicy odour resembling that of pepper and ginger oils, and having the following characteristics: $d_{20°}^{20°}$, 0.8484; $n^{20°}$, 1.4769; $[\alpha]_D$, −40.1°; solid. p., −6°; acid val., 7.2; sap. val., 8.9; sap. val. after acetylation, 12.8; and sol. in 20 vol. of 95% alcohol. The oil contained: *n*-hexadecane, 0.7; *n*-heptade-

cane, 6.0; *n*-octadecane, 5.3; *n*-nonadecane, 5.8; *n*-eicosane, 4.7; *n*-heneicosane, 2.5; α-thujene, 1.7; terpinolene, 1.3; zingiberene, 7.0; *p*-cymene, 1.3; *p*-methoxy acetophenone, trace; dihydrocarveol, 4.3; phenethyl alcohol, 2.1; and 2 new monocyclic sesquiterpenes (b.p. 235° and 247°), 15.5, 11.1% respectively (Handa *et al.*, *Parfum. u. Kosmetik*, 1963, **44**, 233).

Besides fruits, the roots and thicker parts of stem are cut and dried and used as an important drug (*Piplamul*) in the Ayurvedic and Unani systems. In some hilly parts of Vishakhapatnam district in Andhra Pradesh, long pepper is grown for its roots. It is grown as a perennial in small plots of 25–50 cents and the roots are collected for 10–30 years, the first harvest commencing from 18 months after planting. The stems close to the ground are cut and the roots dug up, cleaned and heaped in shade for a day, after which they are cut into pieces of 2.5–5 cm. long. On an average 500 kg. of roots are obtained per hectare. The produce is graded and packed in gunnies into packets of 37.2 kg. each. *Pipal* roots from Vishakhapatnam are exported to Bombay, Surat, Ahmadabad, Kanpur, Madras and Tuni (Parthasarathy & Narasimha Rao, *Andhra agric. J.*, 1954, **1**, 299; Information from Shri Bhujanga Rao, Dep. Agric., Andhra Pradesh).

There are three grades of *Piplamul*, Grade I with thick roots and underground stems fetching higher price than Grade II or III, which comprise either thin roots, stems or broken fragments. Commercial drug consists almost entirely of transversely cut pieces (length, 5–25 mm.; diam., 2–7 mm.) which are cylindrical, straight or slightly curved, and some with distinct, swollen internodes showing a number of leaf and rootlet scars. The surface of the pieces is dirty, light brown in colour. The drug has a peculiar odour and a pungent bitter taste producing numbness on the tongue. It contains piperine (0.15–0.18%), piplartine (0.13–0.20%), and traces of a yellow crystalline pungent alkaloid (m.p. 116–17°). Other constituents found in the drug include triacontane, dihydrostigmasterol, an unidentified steroid (m.p. 122–23°), reducing sugars and glycosides. Two new alkaloids, named piperlongumine (probably identical with piplartine; $C_{17}H_{19}O_5N$, m.p. 124°; 0.2–0.25%) and piperlonguminine ($C_{16}H_{19}O_3N$, m.p. 166–68°; 0.02%), besides piperine have been isolated from the roots in another investigation (Parthasarathy & Narasimha Rao, loc. cit.; Atal & Banga, *Indian J. Pharm.*, 1962, **24**, 29, 105; *Curr. Sci.*, 1963, **32**, 354; Atal & Ojha, loc. cit.; Koman, 1918, 18, 27; Chatterjee & Dutta, *Sci. & Cult.*, 1963, **29**, 568; *Tetrahedron Lett.*, 1966, 1797; *Tetrahedron*, 1967, **23**, 1769).

Dep. Agric., Andhra Pradesh

FIG. 34—PIPER LONGUM—ROOTS (PIPLAMUL)

The fruits as well as the roots are attributed with numerous medicinal uses, and may be used for diseases of respiratory tract, viz. cough, bronchitis, asthma, etc.; as counter-irritant and analgesic when applied locally for muscular pains and inflammation; as snuff in coma and drowsiness and internally as carminative; as sedative in insomnia and epilepsy; as general tonic and haematinic; as cholagogue in obstruction of bile duct and gall bladder; as an emmenagogue and abortifacient; and for miscellaneous purposes as anthelmintic, and in dysentery and leprosy (Atal & Ojha, loc. cit.).

Alcoholic extracts of the dry fruits and aqueous extracts of the leaves showed activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. Ether extract of the fruits showed larvicidal properties [George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42; Gokhale *et al.*, *J. Univ. Bombay, N.S.*, 1947–48, **16A**(23), pt 5, 47].

In Chota Nagpur the root is used to ferment rice beer. In Andaman Islands, the leaves are chewed like betel leaves [Fl. Assam, IV, 34; Srinivasan, *Bull. bot. Surv. India*, 1960, **2**(1 & 2), 15].

P. nigrum Linn. BLACK PEPPER

D.E.P., VI(1), 261; C.P., 896; Fl. Br. Ind., V, 90.

SANS.—*Maricha, ushana, hapusha*; HINDI, BENG.—*Kalimirch, kalamorich, golmorich*; MAR.—*Kalimirch, mire*; GUJ.—*Kalamari, kalomirich*; TEL.—*Miriyala tige*; TAM.—*Milagu*; KAN.—*Kare menasu*; MAL.—*Kurumulaku, nallamulaku*.

A branching, climbing perennial shrub, mostly found cultivated in the hot and moist parts of India, Ceylon and other tropical countries. Branches stout, trailing and rooting at the nodes; leaves entire, 12.5–17.5 by 5.0–12.5 cm., very variable in breadth, sometimes glaucous beneath, base acute rounded or cordate, equal or unequal; flowers minute in spikes, usually dioecious, but often the female bears 2 anthers, and the male, a pistillode; fruiting spikes very variable in length and robustness, rachis glabrous; fruits* ovoid or globose, bright red when ripe; seeds usually globose, testa thin, albumin hard.

Pepper is one of the most ancient crops cultivated in India and has probably originated in the hills of south-western India, where it is met with in a wild state in the rain forests from North Kanara to Kanniyakumari. The pepper vine in its wild state is mostly dioecious and consequently rarely sets fruit. Under cultivated condition, however, the fruiting is very much better, since most of the cultivated types are bisexual. The bisexual types have probably originated from the wild ones, as a result of continuous selection and vegetative propagation by man through ages. It is probable that the cultivated forms in different regions have originated from wild peppers of the same region, as they show considerable variation in habit, size and shape of fruits and their fruiting behaviour (Burkill, II, 1747, 1749; Barber, *Agric. J. India*, 1906, **1**, 163; Abraham, *Farm Bull.*, No. 55, 1959).

The bisexual cultivated types of pepper exhibit great variability in the percentage of bisexual or productive flowers on their spikes. The higher the percentage of bisexual flowers in a type, the greater is its productivity. In the Kerala coast, the percentage of bisexual flowers in the cultivated types varies from 10 to 98. Most of the very high-yielding and popularly cultivated types produce as much as 70 to 98 per cent bisexual flowers. Under intense shade conditions the bisexual types produce more female flowers and less of hermaphrodite flowers (Abraham, loc. cit.).

Several types of pepper are known in cultivation and their precise identification is rather difficult, since some of them go by different names in different regions. Generally, the choice of a type depends on its yield and resistance to diseases and pests. The characteristics of important types of pepper grown in various regions are given in Table 7. It is stated that a high yielding type should have long spikes, with good-sized fruits compactly set all over. Generally, the Travancore types are hardy, their shoots strike roots easily and make rapid growth. Some of them are more short-lived than the types of other regions, but bear profuse crops. Almost all the types cultivated at present are selections from wild plants. There is considerable scope for combining the high yield, hardiness, disease resistance, and quality attributes

I.C.A.R., New Delhi

FIG. 35—PIPER NIGRUM—HARVESTED SPIKES

* Generally described in most publications as berries; the fruits are botanically drupes.

TABLE 7—CHARACTERISTICS OF SOME IMPORTANT TYPES OF P. NIGRUM GROWN IN INDIA*

Types	General characters	Agricultural performance	Regions where popular
Balamcotta	Leaves large, light green; spikes long and straight and loosely packed with pale green fruits which are lighter than those of Kalluvalli	Fairly heavy and regular bearer; flushes all over at the same time so that harvesting is done at one stretch; yields 38% dried pepper	N. Travancore, N. Malabar and S. Kanara
Cheria kaniakadan	Leaves small, elliptic; spikes of medium length, closely set with medium-sized, dark green fruits	Popular type; regular and heavy yielder of high quality; wilt-resistant; yields 42% dried pepper	N. and Central Travancore
Cheriakodi	Leaves narrow, dark green; spikes short, with dark or pale green fruits which are smallest among all types	Dwarf and sturdy type, bearing in alternate years; quality high; yields 38% dried pepper	N. Travancore and N. Malabar
Chumala	Leaves large, pale green; spikes long and straight with large pale green fruits	Prefers shaded and protected situations like Balamcotta; regular bearer; early type; yields 33% dried pepper	Central Travancore
Doddaga	Leaves broad; spikes long, curved; fruits large among Mysore types	Uniform yielder, esteemed for making white pepper; yields 38% dried pepper	N. Kanara
Kalluvalli	Leaves dark green; spikes short and twisted with close set, medium-sized dark green fruits	Hardy, regular bearer; drought and wilt-resistant; good yielder; yields 42% dried pepper	N. Travancore, N. Malabar and S. Kanara
Karimunda (Karivalli)	Leaves oval or circular, dark green; spikes of medium length, closely set with dark green medium-sized fruits	Quick growing, early bearer but short-lived (15 years); yields high quality heavy pepper; yields 40% dried pepper	N. and Central Travancore
Karimcotta	Leaves large, dark green; spikes short, curved with closely set large, dark green fruits	Hardy, regular bearer, good yielder; yields 42% dried pepper	N. Travancore and N. Malabar
Karivilanchi	Leaves ovate and medium-sized; spikes fairly closely set with medium-sized, dark green fruits	Hardy, regular bearer; good yielder, producing pepper of good quality; yields 36% dried pepper	S. and Central Travancore
Kottanadan	Leaves medium-sized; spikes long, straight, closely set with medium-sized, dark green fruits	Heavy yielder, regular bearer and hence very popular; yields 43% dried pepper	S. and Central Travancore
Kumbhakodi	Leaves large; spikes long, straight usually closely set with medium-sized, dark green fruits	Grown mixed with other types; regular bearer and good yielder; yields 34% dried pepper	Central Travancore
Kuthiravali	Fruits large and elliptic, set closely on the spike; in certain localities, it has shorter spikes	Yields only in alternate years; good yielder; yields 36% dried pepper	S. Travancore
Malligesara	Leaves medium sized; spikes long, well filled with small fruits	Regular bearer, heavy yielder; yields 42% dried pepper	N. Kanara
Narayakodi	Leaves small, ovate with wavy margins; spikes short and twisted, closely set with medium-sized, dark green fruits	Quick growing, early bearer, and high yielder; quality of pepper high	Central and N. Travancore
Perumkodi	Leaves large, oval; spikes fairly long, straight, closely set with dark green, medium-sized fruits	Grows to considerable height, lives long (100 years); yields in alternate years; yields 40% dried pepper	Central and N. Travancore
Tattisara	Leaves narrow, long, dark green; spikes long with fruits larger than in Malligesara	Leaves drop largely when the fruits ripen	N. Kanara
Uthirancotta	Leaves light green, tough and leathery; spikes long and slender, sparsely set; fruits light green, larger than those of Kalluvalli	Hardy type profusely tillering; generally poor yielder but bearing good crops in certain years; fruits shed early; yields 38% dried pepper	N. Travancore and N. Malabar
Wokalamorata	Leaves long, light green; spikes short	Early ripening; fruits shed when ripe and should be gathered before fully ripe	Mysore

*Abraham, *Farm Bull.*, No. 55, 1959, 14-27; *Rep. Spices Enquiry Comm.*, 1953, appx VI; Yegna Narayan Aiyer, 307; *Mem. Dep. Agric. Madras*, No. 36, 1954, 628; Barber, *Bull. Dep. Agric. Madras*, No. 56, 1909, 128.

by hybridization of types with known characteristics. Some crosses have already been evolved at the Pepper Research Station, Panniyur (Kerala). Of these, the hybrid, *Panniyur I*, a progeny from a cross between *Taliparamba No. I*, noted for its high yield, and *Uthirancotta*, a type valued for its hardiness and less susceptibility to diseases, has been found to be very promising. An outstanding feature of this hybrid is its high yield, going up to 10.5 kg. (of green fruits) per vine in the third year of bearing. *Panniyur I* is a good hardy climber and has long spikes with close set, large fruits. It starts yielding even from the second year onwards [Khan, *Indian Fmg, N.S.*, 1959–60, **9**(12), 33; Aiyadurai, 61; Information from Pepper Research Officer, Pepper Research Station, Taliparamba].

Cultivation

In India, pepper is cultivated mostly as a mixed crop in homestead gardens. Under this system, the vines are trained on to existing trees like jack, mango, coconut or arecanut. The number of vines grown in this way is small, generally not more than 100. But the vines receive intensive care and continue to be productive up to 60 or even 100 years. The vines are also grown as an inter- or subsidiary crop along with other plantation crops like coffee, cardamom, arecanut, coconut and orange. This practice is more common in North Kanara, Coorg and parts of Kerala. As a pure crop, pepper is grown on a plantation scale only in small areas in the sub-montane tracts and lower altitudes in South Kanara, Malabar, Wynaad and Travancore. It is stated that a plantation of more than 4 hectares (10 acres) is not economical (Yegna Narayan Aiyer, 296; *Rep. Spices Enquiry Comm., Indian Coun. agric. Res., New Delhi*, 1953, 15–16; Abraham. *Farm Bull.*, No. 55. 1959).

India has been a leading producer and exporter of pepper. Before World War II, India, Indonesia, Ceylon, Cambodia and Sarawak were the main producers, but in recent years, Brazil and Malagasy have also emerged as significant producers. Table 8 summarizes the extent of pepper production in different countries.

Major pepper producing areas are concentrated in regions where not only climatic and soil conditions are suitable, but also labour is easily available for its intensive care and handling. In India, Kerala on the west coast produces nearly 95 per cent of the total output, while in Indonesia, cultivation is concentrated in the southern part of Sumatra and neighbouring islands. In Malaysia, major production is obtained from northern Sarawak, while in Brazil it is chiefly from the region near the mouth of Amazon [Kevorkian, *Foreign Agric.*, 1965, **3**(29), 11].

In India, pepper is grown mainly in Kerala, Madras and Mysore and to a very small extent in Assam. In Kerala, pepper is grown in all the nine districts, the major ones being Cannanore, Calicut, Kottayam and Trivandrum districts. In Madras, it is grown to a small extent in the Nilgiri and Kanniyakumari districts. Among the districts of Mysore State, the

TABLE 8—WORLD PRODUCTION OF BLACK PEPPER*

(Qty in thousand tonnes)

Countries	Pre-war	Post-war								
	1935–39 (av.)	1947–49 (av.)	1950–54 (av.)	1955–59 (av.)	1960	1961	1962	1963†	1964†	1965–66
India	15.01	31.30	26.35	26.39	28.45	28.36	30.49	29.00	27.00	23.30
Indonesia	58.33	2.40	7.86	20.28	26.00	24.00	18.14	25.00	30.00	n.a.
Sarawak	2.40	0.32	6.08	13.89	7.26	8.17	9.39	11.70	13.20	18.20
Ceylon	2.27	2.49	4.78	6.15	8.62	8.17	8.17	n.a.	n.a.	n.a.
Cambodia	4.99	1.09	1.10	1.31	1.99	1.63	1.27	1.40	1.40	n.a.
Malagasy	0.27	0.27	0.42	0.59	1.11	1.27	1.36	1.40	1.40	1.60
Brazil	..	..	0.56	2.22	3.90	4.99	4.08	6.40	6.00	9.00
Others	0.28	1.00	1.09	1.11	..	..	..	..	..	..
Total	83.55	38.87	48.24	71.94	77.33	76.59	72.90	74.90	78.00	52.10

* *Export Prospects of Pepper, Nat. Coun. appl. econ. Res., New Delhi*, 1965, '66–67. † *Spices Bull.*, Seminar number, 1965.
n.a.—not available.

TABLE 9—AREA AND PRODUCTION OF BLACK PEPPER IN INDIA (DISTRICT-WISE)

Districts	Area (in hectares)					Production (in tonnes)				
	1961-62	1962-63	1963-64	1964-65	1965-66	1961-62	1962-63	1963-64	1964-65	1965-66
Cannanore	42,420	43,160	43,765	43,765	43,765	8,850	8,440	6,975	6,860	6,450
Calicut	15,890	15,880	15,990	15,900	15,990	3,200	2,600	2,620	2,515	2,390
Kottayam	14,010	13,750	15,080	14,300	14,450	4,990	4,740	4,460	4,450	4,500
Trivandrum	8,580	8,330	8,430	8,430	8,430	3,520	3,260	3,070	3,160	3,160
Ernakulam	6,940	6,730	6,800	6,800	6,810	2,910	2,040	2,030	2,025	2,025
Quilon	5,170	4,690	4,750	4,765	4,765	2,055	2,080	2,020	2,025	2,005
Palghat	3,380	3,440	3,480	3,480	3,480	690	530	520	500	490
Alleppey	1,610	1,390	1,340	1,275	1,275	520	440	410	370	355
Trichur	680	720	740	740	740	310	320	320	320	320
TOTAL (Kerala)	98,680	98,090	100,375	99,455	99,705	27,045	24,510	22,425	22,225	21,695
Kanniyakumari	210	210	215	220	120	40	40	40	40	30
Nilgiris	70	80	85	90	100	20	20	20	20	20
TOTAL (Madras)	280	290	300	310	220	60	60	60	60	50
S. Kanara	870	1,345	1,360	1,360	1,067	900	900	1,280	1,280	913
N. Kanara	1,060	830	880	870	870	300	540	540	540	522
Coorg	290	250	430	430	429	140	140	185	185	161
Shimoga	100	100	100	100	101	6	6	6	6	6
Chickmagalur	4	4	8	8	8	1	(a)	1	1	1
Hassan	..	16	16	16	16	..	1	1	1	n.a.
TOTAL (Mysore)	2,324	2,545	2,794	2,784	2,491	1,347	1,587	2,013	2,013	1,603
TOTAL (all India)	101,284	100,925	103,469	102,549	102,416	28,452	26,157	24,498	24,298	23,318

(a)—negligible. n.a.—not available.

important areas are in North and South Kanara. Table 9 gives the area and production of pepper in the different districts.

Climate and Soil—The pepper plant is a climbing vine found growing up to an altitude of 1,500 m., but thrives best at about 500 m. It is usually raised on established supports. Pepper requires a warm and humid climate. It thrives in places where the annual rainfall is well over 200 cm. and in any case not less than 125 cm. On the eastern slopes of the Nilgiris, which receive hardly 120 cm. of rain, pepper is being grown fairly successfully on a small scale as an inter-crop in tea and coffee plantations. Similarly in some parts of Tirunelveli district, pepper is grown in the shade of tea, coffee and cardamom plantations. Pepper plants are pollinated by rain-water and consequently satisfactory yields are obtained when frequent showers of rain occur during blossoming period. In the important pepper growing areas, the maximum temperature during the hot weather seldom exceeds 40° and the lowest temperature may be about 10°. In parts of South India, Assam and in the Darjeeling district of West Bengal, pepper is found to tolerate even lower temperature (Abraham, loc. cit.; Yegna Narayan Aiyer, 296; Brown & Reader, *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 195).

Pepper thrives best on virgin soil rich in humus and other plant nutrients. Naturally well-drained, red laterite soils or alluvial soils rich in humus seem to be highly suitable for this crop. Soils 1.2 to 1.5 m. in depth with granite rock underneath, and inter-mixed with boulders are considered ideal for this crop. The soil should not dry up during the dry months as to kill the vines or get flooded during the

rains. In Kerala, major part of the pepper cultivation is on laterite or sandy loam along the alluvial banks of rivers. Compared to the soils of Indonesia, which are mostly volcanic, the soils of pepper tracts in India are poor and consequently yield less. In order to improve production, cultivation of pepper should be encouraged in those areas where soil is more suitable. From this viewpoint, areas in Mysore State are reported to be better than Kerala (Abraham, loc. cit.; Yegna Narayan Aiyer, 297; *Export Prospects of Pepper, Nat. Coun. appl. econ. Res., New Delhi*, 1965, 25).

Preparation of land—As pepper is a climbing vine, supports or standards have to be provided for the plants to grow on. The standards usually preferred are quick growing trees, which not only provide support, but also shade. While in India, living trees are mainly used as supports or standards, in Indonesia, Malaya and other South-East Asian countries, dead woods are used, since in these areas shade is not a big problem and also the equatorial climate with almost daily rainfall makes it unnecessary. Some of the trees preferred as standards are *Erythrina variegata* var. *indica*, *Garuga pinnata*, *Oroxylum indicum*, *Spondias pinnata*, *Ceiba pentandra*, and *Grevillea robusta*. Occasionally wooden poles and stone or concrete pillars have been used as standards, though this practice is rare. Bamboo or wooden poles are used as temporary standards, till the permanent ones grow sufficiently (Abraham, loc. cit.).

For raising shade or standard trees, pits are dug at 2.5–3.0 m. apart and standards raised either by cuttings or as seedlings. Planting is done in April–May during the early rains so that these standards grow sufficiently to allow pepper vines to be planted in July–September. When planted as a mixed crop in coconut, arecanut, tea or coffee plantations, the main crop or the shade trees serve as standards besides providing the shade (Yegna Narayan Aiyer, 297–98; *Mem. Dep. Agric. Madras*, No. 36, 1954, 626).

Propagation—The pepper vine can be propagated either vegetatively or by seeds. Vegetative propagation is universally adopted, because raising of plants through seed is slow, uncertain and the seedling progeny takes a much longer period to attain maturity and does not always behave true to the parent. However, it is believed that the plants raised from seeds live longer, and give heavier crops in later years than plants raised vegetatively. For raising seedlings, selected, well ripened fruits are soaked in water for 2–3 days, the outer skin removed, the seeds dried in shade and sown in nursery beds. They are transplanted when they have developed 4–5 leaves.

I.C.A.R., New Delhi

FIG. 36—PIPER NIGRUM—GROWN ON BAMBOO SUPPORT

Experiments recently conducted in Panniyur have shown that sowing fruits with the coats give quicker germination than without them (Nicholls & Holland, 305; Abraham, loc. cit.).

Methods of vegetative propagation vary in different places. There are two types of vegetative shoots preferred for planting, viz. the runners which are usually confined to the bottom portion of the vines, and the terminal shoots towards the top region. The runners form the most common material for propagation. Selection of shoots for the propagation is usually done in October, when the vines are in full crop and their cropping behaviour and other features are easily decided. The healthiest shoots among the ones found in a clump are selected, and they are kept coiled up on forks, in order to prevent them from coming in contact with soil and rooting prematurely. These shoots are separated from the parent vine, cut into lengths of four or five nodes and planted either in the field or are rooted in baskets and then planted in the field as rooted cuttings. The usual practice is to plant cuttings in a nursery towards the end of October and transplant them in the field during the next rainy season (July). Experiments at the Pepper Research Station, Panniyur, have shown that it is best to raise rooted cuttings in special bamboo baskets, 25–30 cm. in length and 10.0–12.5 cm. in diameter. A couple of cuttings with four nodes each are planted in each basket and the basket kept under thatched roof or a *pandal*, and regularly watered until the cuttings strike roots. It is estimated that 750–1,000 vines are planted per hectare (Abraham, loc. cit.).

In some areas, particularly in North Kanara, the terminal shoots of the top fruiting branches are preferred. Plants raised from such cuttings are said to yield even in the second year of planting and produce a satisfactory crop from the fourth year onwards while vines raised from runner shoots give satisfactory yields only from the sixth or seventh year. The former, however, are short-lived as compared to the latter, their longevity being about 15 years. Further, the removal of the fruiting branch from the top of the vine is reported to lead to a reduction in the crop. In spite of this, the practice is prevalent to an appreciable scale, particularly in countries like Indonesia, Cambodia, Malaya, etc. (Abraham, loc. cit.).

Propagation by layering is adopted on a small scale by some growers in Malabar and South Kanara, where selected runner shoots from vines of known performance are layered in bamboo baskets 15–20 cm.

I.C.A.R., New Delhi

FIG. 37—PIPER NIGRUM—GROWING ON FOREST TREES

in diameter. Within four to six weeks the shoots strike root, and are then carefully separated and planted. Raising pepper vines by single node cuttings instead of the usual 4–5 nodes, has been tried at the Pepper Research Station, Panniyur. Cuttings consisting of a single node with 5 cm. of stem above and below the node have been found to be economical [Abraham, loc. cit.; Kurup, *Indian Fmg, N.S.*, 1955–56, **5**(12), 21].

Propagating pepper vines by grafting has been tried, particularly for exploiting the possibilities of using as rootstock, varieties and species known for resistance to diseases. Successful grafts by inarching or side grafting have been obtained with some of the wild species and varieties of pepper and also with betel vine (Abraham, loc. cit.).

Planting—The planting of the pepper vine is done either in July or August. The pits for planting are made preferably on the north and north-eastern sides of the standard so that the severe western sun is avoided. Pits about 45 cm. deep are dug in a semi-

circular form below and around the standard and these are filled about one half with good jungle soil. In the case of unrooted cuttings, 3–7 cuttings are planted in each pit. If all the cuttings strike root, two are retained and the remaining ones removed to fill in blanks where necessary. In the case of rooted cuttings generally a couple of cuttings are planted without disturbing the roots, the soil firmly pressed and heaped up a little to prevent water from collecting around. The pepper vine makes rapid growth and at the end of the first year may be 1.0–1.5 m. long. As the vines grow they have to be tied to the standard usually at intervals of 30 cm. Tying is done regularly during the first 3–4 years, but when once the vines establish themselves on the standards this may be discontinued (Yegna Narayan Aiyer, 302–03; Abraham, loc. cit.; *Mem. Dep. Agric. Madras*, No. 36, 1954, 626–27; Menon, *Indian J. agric. Sci.*, 1949, **19,** 89).

Manuring—Pepper is an exhausting crop and the soil needs high level of nitrogenous manuring. In India, where pepper is grown mostly in homestead gardens, not much of manuring is done except what is given to some of the trees serving as standards. Recent experiments in Kerala have shown that an application of a fertilizer mixture made up of ammonium sulphate, rock phosphate and potassium chloride in the proportion 6:9:12 nearly doubles the yield. Additional application of cowdung and green manure will result in still better yields [Kalarickal, *Fertil. News*, 1961, **6**(1), 22; *Indian Fmg, N.S.*, 1961–62, **11**(5), 30; *Madras agric. J.*, 1955, **42,** 403].

In Malaya, the pepper vine is heavily manured and different kinds of guano, fish meal and prawn meal are used. Mulching is also practised by growing cover crops like *Crotalaria* and *Calopogonium*. Additional manuring with potassium muriate and rock phosphate has also been found to be beneficial [Nambiar, *Arecan. Bull.*, 1954, **5**(2), 20; Sandford, *Malay. agric. J.*, 1952, **35,** 208; Brown & Reader, *Colon. Pl. Anim. Prod.*, 1952–53, **3,** 195].

Post-planting operations—Widely different practices are adopted once the vines are established and well grown. In Malabar and South Kanara, diggings and weedings are done, once during south-west monsoon and again after north-east monsoon, to conserve soil moisture, and prevent weed growth and surface run off. In some areas contour bunding and terracing are done to prevent soil erosion. In Malaya, pruning is often practised to promote branching during the first few years; in some places the vines are lowered as in the case of *P. betle* and buried in the ground in order to induce more vigorous growth and ensure larger crop (Abraham, loc. cit.; Grist, 268; Nicholls & Holland, 306).

Diseases and Pests—The wilt and *pollu* are the two important diseases of pepper. The wilt is characterized by the death and decay of the roots, yellowing and shedding of the leaves and the ultimate drying up of the plant. It is widely prevalent in areas where the plant is raised in poor, shallow or ill-drained soils and in exposed situations, particularly in summer. The rotting of the root is attributed to the fungus *Phytophthora* and a number of fungicides have been tried to control the fungus. Other control methods include burning the affected plants, applying slaked lime near the surface roots, soon after the first monsoon showers, and keeping the soil well drained and clean. Attempts have also been made to evolve and select wilt-resistant types suited to the various areas and to graft susceptible types on to rootstocks of resistant types (Menon, loc. cit.; Abraham, loc. cit.).

The Hollow Berry or *pollu* is a more serious disease as it not only causes the hollowness of the fruits, but also leads to their complete destruction. *Pollu* is attributable to two main causes, viz. a fungus, *Colletotrichum* sp., and a flea beetle, *Longitarsus nigripennis* Motsch. Infection by the fungus is said to start from the leaf and the stem and finally spreads to the spikes and the fruits. As a result of the infection the spikes drop down and the fruits borne on them are hollow and light when dried. The disease is prevalent in areas where the shade is too dense. Spraying the affected vines with Bordeaux mixture soon after the fruits are set has been found effective in reducing the extent of damage.

The flea beetle, *Longitarsus nigripennis* Motsch., lays eggs inside the fruits, where they hatch in about a week and the grubs finally eat away the kernel leaving only a light hollow shell. Spraying with 0.25 per cent DDT has been found efficacious; other insecticides found effective are Lindane, Dieldrin and Malathion [Abraham, loc. cit.; Menon, loc. cit.; *Cashew & Pepper Bull.*, 1957–58, **2**(9), 17; Nambiar & Kurian, *Indian Fmg, N.S.*, 1962–63, **12**(4), 17; Rehiman & Nambiar, *Madras agric. J.*, 1967, **54,** 39].

Processed black pepper in storage is rarely attacked by pests. But when the moisture exceeds 12–13 per cent, book lice or *Psocids*, cereal mites, grain beetles, cigarette beetles and drug-store beetles occasionally

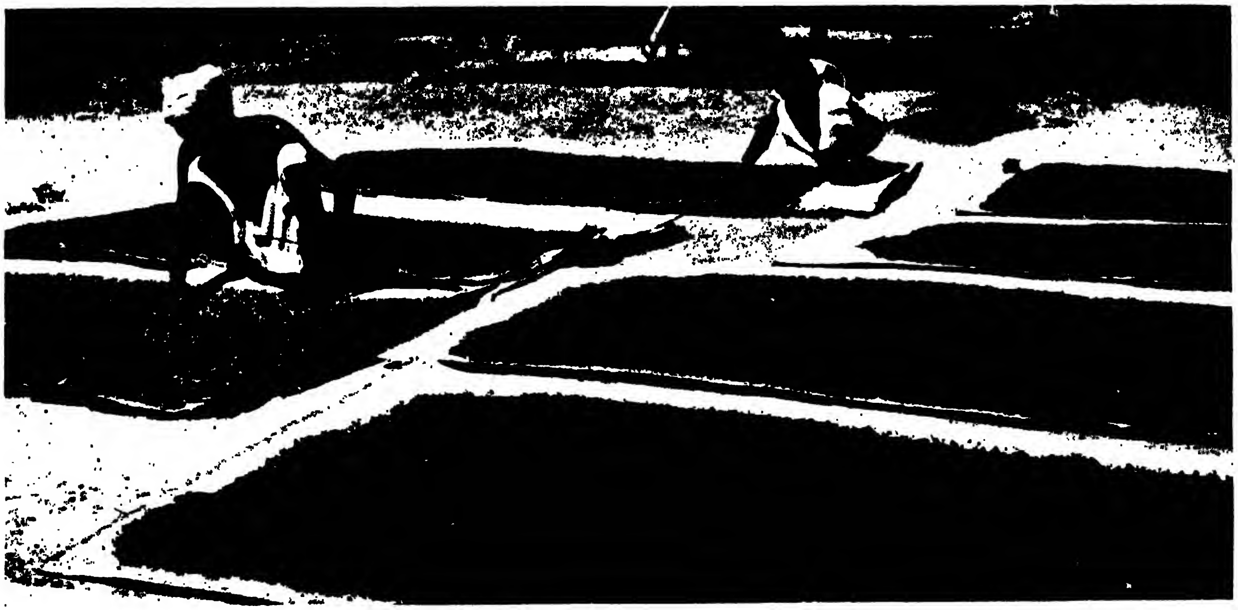


FIG. 38—DRYING OF PEPPER

make their entry. They are best avoided by thoroughly drying the pepper before storing it. The drug-store beetle, *Sitodrepa panicea*, causes considerable damage in some areas in Kerala. Fumigation of dry pepper with Chlorosol has been found effective. Among the fungi infesting stored pepper are *Aspergillus niger* van Tiegh., *A. oryzae* (Ahlburg) Cohn and *A. glaucus* Link. Mould formation and insect infestation can be controlled by drying the black pepper properly [Abraham, *Cashew & Pepper Bull.*, 1957–58, **2**(5), 3 ; *Food Sci.*, 1957, **6**, 35, 111].

Harvesting and Yield—The pepper vine starts bearing from the third year of its growth. An adult vine yields annually *c.* 0.5 kg. dried fruits under Indian conditions. The yield goes on increasing as the vines get older up to about the tenth year. In well cared gardens, tenth to twenty-fifth year may be reckoned as the best period ; after the thirtieth year, the yield begins to decline, though in homestead gardens vines as old as 100 years continue to be productive. Usually there are two crops in a year, one in August–September and the other in March–April. On the west coast, the flowering commences in June–July soon after the commencement of the south-west monsoon. Sometimes the pre-monsoon showers also initiate flowering. The harvest season of pepper extends from the middle of December to the middle of March in the coastal areas. On the foot-hills of the ghats and in colder regions like Assam, the harvests are considerably delayed and extend up to April. The lower the temperature and higher the elevation, the later is the cropping period. When the fruits are ready for harvest, the whole spikes are removed from the vines with the aid of a ladder. They are dried in the sun for 3–4 days, and the fruits separated from the stalks by beating the dried spikes with a stick or by trampling under foot. When completely dry, the outer skin of the fruits becomes black and wrinkled. It is estimated that 100 kg. of green pepper roughly yield 33 kg. of dried pepper.

The yield of pepper varies widely in the different producing areas depending on the elevation, temperature, distribution of rainfall, soil fertility, cultural practices, types grown and the age of the pepper bushes. Timely rainfall and proper climatic conditions during flowering, fruit setting and fruit development are important factors affecting yield.

The yield of pepper per vine varies from place to place and from type to type. The type *Balamcotta* on an average yields 1.0–1.5 kg. dried pepper per vine in Wynaad, 0.50–0.75 kg. in Kottayam, 1 kg. in Chirakkal, and 1 kg. in Mysore, though in Mysore its maximum yield has been found to be 3.0–3.5 kg. Another good yielder is *Karimcotta* which on an average gives 1.0–1.25 kg. dried pepper (Menon, *Indian J. agric. Sci.*, 1949, **19**, 89).

In Malaya, pepper vines yield about 1–2 kg. dried pepper per vine in the first year of harvest and

the yield goes up gradually to about 4 kg. per vine by the seventh year and then declines. In Indonesia, the yield from pepper vines is generally stated to be c. 0.5 kg. dried pepper in the first year of cropping, rising to 1.5 or 2 kg. per vine by about the seventh year. Vines yielding up to 12.5 kg. dried pepper have also been known [Nambiar, *Arecan. Bull.*, 1954, **5**(2), 20 ; Brown & Reader, *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 195].

In India, the average yield of commercial black pepper has been found to vary from 110 to 335 kg. per hectare. The lowest yield is reported from the Malnad areas of Mysore where the average yield does not exceed 110 kg./ha. In Malabar and South Kanara, the average yield of pepper is estimated to be 280–335 kg./ha. The highest yield is reported from Quilon district where the average yield has been nearly 440 kg./ha. (*Rep. Spices Enquiry Comm.*, 1953, 18 : *Export Prospects of Pepper*, 1965, 84).

Compared to Malaya, Cambodia and other countries, pepper yield in India on the whole is poor. The yield in Malaya is reported to be 2,240 kg. of green pepper per hectare in the third year and this steadily goes up to about 4,480 kg./ha. from the fifth to the seventh year. In Sarawak, very high yields are reported starting from about 7,840 kg. in the third year to 13,400–17,920 kg. per hectare by the tenth year. After the tenth year, there is a gradual decrease in yield. The average yield of green pepper in Ceylon is about 2,500 kg., in Sumatra 1,350 kg. and in Cambodia 1,450 kg./ha. The high yield of pepper in Malaya, Sarawak and other areas is due to the heavy manuring, uniformly distributed rainfall and the judicious and systematic pruning of the pepper vines adopted [Nambiar, *Arecan. Bull.*, 1954, **5**(2), 20 ; de Waard, *World Crops*, 1964, **16**(3), 24 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 631 ; *Export Prospects of Pepper*, 1965, 64].

Processing

Black pepper—Black pepper consists of the dried, fully developed unripe fruits. It is nearly globular in shape, about 4–5 mm. in diameter with a characteristic coat with deep set wrinkles. The pericarp is thin and encloses a single seed with a hollow centre. The perisperm is horny in the outer part and floury around the central cavity (Parry, J. W., 1962, 67).

For preparing black pepper, the freshly harvested spikes are spread on mats or concrete floors and dried in the sun for about a week with frequent turning over to prevent infection by mildew. Spikes which have dropped prematurely from the vines are also used. During drying, the green or red fruits gradually change in colour to dark brown or almost black and their skin becomes tough and wrinkled. The fruits are detached from the stalks by beating the heaped up material with sticks or treading upon it barefooted, the latter method entailing the minimum wastage. They are then separated out from the stalks, leaflets, undersized and unripe fruits and other impurities by hand picking and winnowing. On some of the large estates, fresh pepper spikes are dried artificially in smoke-houses by means of an open fire, and the fruits then separated out by machines. Such smoke-dried black pepper has a peculiar smoky odour and is considered a delicacy by certain sections of consumers. In Malaya, the freshly harvested spikes are said to be immersed in boiling water for a short time prior to drying in order to ripen the fruits which are yet green and also to quicken the process of subsequent drying [Guenther, V, 137–38 ; Abraham, *Farm Bull.*, No. 55, 1959 ; Sandford, *Malay. agric. J.*, 1952, **35**, 208 ; Brown & Reader, *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 195 ; de Waard, *World Crops*, 1964, **16**(3), 24].

The out-turn of dried black pepper obtained from green fruits varies from 26 to 39 per cent depending

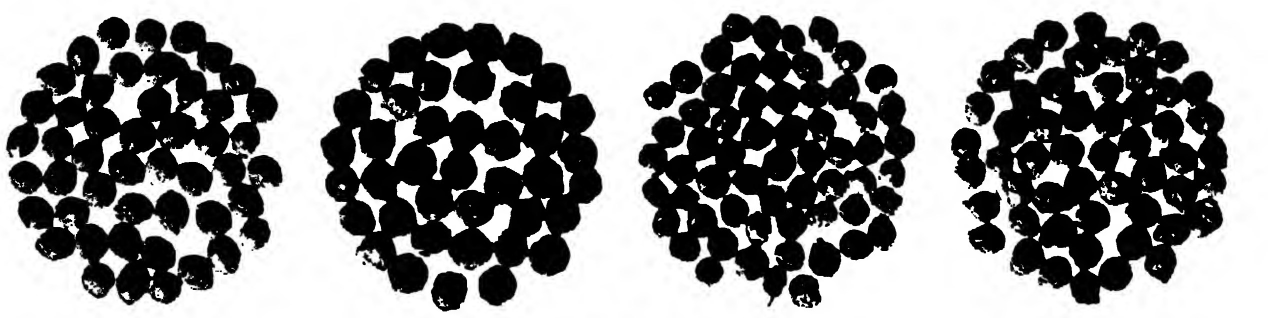


FIG. 39—PIPER NIGRUM—COMMERCIAL SAMPLES

upon the type. Some of the productive, high yielding types such as *Kalluvalli, Uthirancotta, Kottanadan, Karimunda* and *Kaniakadan* give an out-turn of black pepper amounting to 38–43 per cent of the green pepper processed (Abraham, loc. cit.).

White pepper—White pepper consists of dried ripe fruits, freed of their pericarp. In preparing white pepper, the separation is done through the zone of fibro-vascular bundles, i.e. only a part of the mesocarp is removed. In India, the production of white pepper is limited to very small quantities, by some households in Kerala, for medicinal and domestic usage. For this purpose, the fully ripe fruits are rubbed with hand to remove the soft rind, and dried. The white fruits obtained are then washed and finally dried.

Production and export of white pepper is more common in Indonesia, where a large part of the pepper is converted, particularly in Banka Island. For preparing white pepper, the harvesting of the spikes is delayed till all the fruits become red. The spikes are gathered fresh, piled on mats or floors and beaten with sticks or trodden upon till the fruits are detached from their stalks. They are then kept in open concrete tanks, filled with slowly running water for eight to ten days, during which period their skin gets decayed and comes off. The thick mass in the water is often trampled by feet to hasten the skin removal. The white fruits so obtained are washed in water, dried in the sun and finally winnowed. A modification of this process is often practised; the fruits are packed in jute sacks and kept immersed in water, along riverbanks and after 10 days are decorticated, washed, cleaned and dried. If drying has to be delayed, decorticated fruits are kept under water to prevent discolouration. The drying should be complete and the final product should not contain more than 10 per cent moisture. Drying is considered complete only when the fruits run through freely between the fingers or crack well between teeth. Under-dried fruits lack the desirable white colour and the tart, spicy flavour of the product. Besides the above methods, 'Decorticated white pepper' is now prepared from fully matured and dried black pepper by spice millers, by removing the seed coat in specially constructed machines (Guenther, V, 138–39; Thorpe, IX, 277; Sandford, loc. cit.; Brown & Reader, loc. cit.; de Waard, loc. cit.).

A process for the preparation of white pepper by using mature, green fruits instead of ripe, reddish ones has been suggested and an improved method has been worked out at the Central Food Technological Research Institute, Mysore. Fully mature green pepper fruits are cooked in water or steamed for 10–15 minutes, and passed through a pulping machine which separates the skin from the core inside. The skinned fruits are treated with sulphur dioxide or bleaching powder and then dried to yield white pepper. In this process, the out-turn of white pepper from green fruits is 22 per cent [Information from Central Food Technological Research Institute, Mysore; *Spices Bull.*, 1965–66, **5**(1), 23; Lewis *et al.*, ibid., 1965–66, **5**(12), 6].

Ground pepper—In Europe and America, considerable quantities of black pepper are converted into ground pepper. India at present does not produce or export any ground pepper, though there is good demand for it and it commands a higher price. It is suggested that suitable machinery may be installed and ground pepper exported, particularly to some countries in the Middle East (*Export Prospects of Pepper*, 1965, 61).

Utilization and Composition

Utilization—Pepper fruits are used mainly after drying as black pepper or after processing into white pepper. In parts of Kerala, fresh green pepper is sometimes used for preparing pickles. Black and white pepper are among the major condiments employed for seasoning freshly cooked and prepared foods. In U.S.A. and other western countries they are used mainly for preserving meat. Over half of the American consumption of pepper is reported to go into the meat industry for curing and preservation of meat. The whole fruits are added to pickles, certain types of sausages, etc. but the bulk of the product is generally ground before use. Black pepper is mostly used for its characteristic delicate penetrating aroma and pungent, biting taste. White pepper has a similar flavour, but is less pungent. On grinding, white pepper yields a product with low ash and fibre contents and very little pungency. In Borneo, white pepper enters into the composition of the brew employed for growing yeasts (Winton & Winton, IV, 320; Sreenivasamurthy & Krishnamurthy, *Food Sci.*, 1959, **8**, 284; Parry, J. W., 1962, 67; Thorpe, IX, 277; Burkill, II, 1751).

Pepper owes its characteristic pungency and aroma to its oleoresin which can be obtained by extracting the crushed, not fully ripe fruits with volatile solvents. It is a dark or brownish green heterogeneous mass and is widely used in Europe and U.S.A. for flavour-

ing foods. The flavour and degree of pungency of the oleoresin can be standardized to prepare uniform products which are preferred to the natural spice itself (Guenther, V, 144; Arctander, 518–19).

In modern European medicine, black pepper is rarely prescribed, except indirectly, as an ingredient of some combined preparations. In modern Indian medicine, it is much employed as an aromatic stimulant in cholera, weakness following fevers, vertigo, coma, etc., as a stomachic in dyspepsia and flatulence, as an antiperiodic in malarial fever and as an alterative in paraplegia and arthritic diseases. Externally, it is valued for its rubefacient properties and as a local application for relaxed sore throat, piles and some skin diseases (Kirt. & Basu, III, 2134; Snell & Snell, 479; U.S.D., 1955, 1800).

Pepper, particularly its oleoresin, has bacteriostatic and fungistatic properties. The oleoresin at 0.1 per cent concentration inhibits the growth of *Micrococcus pyogenes* var. *aureus* and *Aspergillus versicolor*. Alcoholic extracts of the spice are active against *M. pyogenes* var. *aureus* and *Escherichia coli*. Aqueous extracts of pepper did not show any antibacterial activity, probably due to the low or little concentrations of the oleoresin extracted from the spice by water. Pepper in concentrations of 0.1 per cent or less, lowered the phagocytic activity of leucocytes. Extracts of pepper are found to have a hypercoagulative effect *in vitro*; they lessen the clotting time by accelerating the thrombin activation and lowering the heparin level in clotting systems (Hasselstrom *et al.*, *Food Res.*, 1954, **19**, 373; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42; Subrahmanyan *et al.*, ibid., 1957, **16C**, 240; *Chem. Abstr.*, 1961, **55**, 22610; 1962, **56**, 810).

Pepper retards the development of rancidity in oils and fats, frozen ground pork, beef and lard. This activity has been attributed to the presence of tocopherols in the oleoresin (total, 0.54%; α-tocopherol, 0.1%). The small concentrations of pepper commonly used may, however, not be sufficient to prevent deterioration of foods (*FAO Commodity Bull. Ser.*, No. 34, 1962, 18; Sethi & Aggarwal, *J. sci. industr. Res.*, 1952, **11B**, 468; Chipault *et al.*, *Food Res.*, 1952, **17**, 1; Hasselstrom *et al.*, ibid., 1954, **19**, 373).

Composition—Analysis of a sample of green pepper (after discarding the stalks) gave: moisture, 70.6; protein, 4.8; fat, 2.7; carbohydrates, 13.7; fibre, 6.4; and mineral matter, 1.8%; calcium, 270; phosphorus, 70; iron, 2.4; thiamine, 0.05; riboflavin, 0.04; nicotinic acid, 0.2; and ascorbic acid, 1 mg./100 g.; carotene (as vitamin A), 900 I.U./100 g. (Nutritive Value of Indian Foods, 65, 101, 131).

The numerous types of Indian black pepper are characterized by variations in size, colour, flavour and physico-chemical properties. The weight of pepper varies with the type. Examination of 82 samples, belonging to different types from different localities, showed that weight ranged between 426 and 850 g./litre, the Tellicherry and Baliapatnam types showing the highest values. A bazaar sample of black pepper from Coonoor gave: moisture, 13.2; protein, 11.5; fat, 6.8; fibre, 14.9; carbohydrates, 49.2; mineral matter, 4.4%; calcium, 460; phosphorus, 198; phytin phosphorus, 115; iron, 16.8; ionisable iron, 3.2; thiamine, 0.09; riboflavin, 0.14; and nicotinic acid, 1.4 mg./100 g.; vitamin A value, 1,800 I.U./100 g. Presence of oxalic acid (0.4–3.4%) has been reported [Malik & Bhattacharya, *Agric. Marketing*, 1964–65, **7**(4), 3; Nutritive Value of Indian Foods, 65, 101, 131; Thorpe, IX, 279].

Analysis of 23 types of black pepper from Kerala, South and North Kanara, Coorg and Assam gave the following ranges of values: moisture, 8.7–14.1; total nitrogen, 1.55–2.60; nitrogen in non-volatile ether extr., 2.70–4.22; volatile ether extr., 0.3–4.2; non-volatile ether extr., 3.9–11.5; alcohol extr., 4.4–12.0; starch (by acid hydrolysis), 28.0–49.0; crude fibre, 8.7–18.0; crude piperine, 2.8–9.0; piperine (spectrophotometrically), 1.7–7.4; total ash, 3.6–5.7; and acid insol. ash (sand), 0.03–0.55%. The Kerala types, particularly *Kottanadan, Kumbhakodi* and *Kuthiravali* are fairly high in crude piperine, while the North Kanara types show low values for piperine. Assam types are characterized by a low moisture content, high ether and alcohol extractives and consistently high values for total nitrogen and piperine (Dwarakanath *et al.*, *Food Sci.*, 1958, **7**, 285; 1961, **10**, 1; Rao *et al.*, Paper presented to Indian Standards Convention, 1958; Brown & Reader, *Colon. Pl. Anim. Prod.*, 1952–53, **3**, 195).

Starch is the predominant constituent of pepper. It accounts for 34.1 per cent in black pepper, 56.5 per cent in white pepper and 63.2 per cent in decorticated white pepper. Pepper starch consists of minute polygonal granules resembling those of rice, but much smaller (diam., 0.5–5 μ). The hilum is visible only under high power (Winton & Winton, IV, 335; Allen, I, 519).

Protein of pepper has not been fully investigated. A considerable portion of nitrogen in pepper exists

in a non-proteinous form (such as alkaloids). Of the 12 per cent of water-soluble nitrogen, non-protein N constitutes about 82 per cent and of this more than half is made up of simple amino acids which can be readily utilized by the system. Nitrogen distribution in a sample of whole black pepper (expressed on the nitrogen of the hydrolysate from fat-free material) was as follows: acid sol. humin N, 3.35; amide N, 17.00; basic amino N, 8.68 and basic non-amino N, 3.385 (arginine N, 1.118; histidine N, 3.8; cystine N, 1.280; and lysine N, 5.867); nonbasic amino N, 58.08 and nonbasic non-amino N, 9.58%. Pepper is rich in lysine, histidine and cystine. The following free amino acids have been identified in black pepper: arginine, asparagine, serine, glutamic acid, threonine, β-alanine, γ-aminobutyric acid, and pipecolic acid (Allen, VII, 182; Narasimhamurthy & Ranganathan, *Indian J. med. Res.*, 1937–38, **25,** 373; Rao *et al., J. sci. industr. Res.*, 1956, **15C,** 39).

The ash of black and white pepper contains, respectively: potassium (K_2O), 24.4–34.7, 6.1; sodium (Na_2O), 1.5–5.5, 0.8; calcium (CaO), 11.6–16.1, 33.1; magnesium (MgO), 3.3–13.0, 10.6; iron (Fe_2O_3), 0.3–2.2, 2.0; manganese (MnO_2), 0.2–0.8, 0.5; phosphorus (P_2O_5), 8.5–11.1, 30.0; sulphur (SO_3), 4.0–9.6, 3.5; chlorine, 5.4–8.5, 0.7; and silica, 1.5–6.5, 2.0%. Copper, and iodine (9 μg./100 g. in black pepper) are also present (Thorpe, IX, 278; McCance & Widdowson, 100; Iodine Content of Foods, 123).

Pungent principles—The alkaloid piperine ($C_{17}H_{19}O_3N$, m.p. 129–30°) is considered to be the major constituent responsible for the biting taste of black pepper; it is absent in the leaves and stems of pepper plant. Piperine is sparingly soluble in water, readily so in alcohol, and on hydrolysis splits into piperidine and piperic acid. Piperine is at first tasteless but on prolonged contact develops a sharp, biting taste; alcoholic solution of piperine is intensely pungent. Other pungent alkaloids, occurring in pepper in smaller amounts, are chavicine, piperidine and piperettine. Chavicine, a resinous isomer of piperine, is said to be the most biting ingredient of pepper, and on hydrolysis yields piperidine and *iso*chavicinic acid (an isomer of piperic acid). Piperettine ($C_{19}H_{21}O_3N$, m.p. 146–49°), a vinyl homologue of piperine, was found to the extent of 0.23–0.82 per cent in Indian samples of black pepper; a sample from Ceylon contained 1.56 per cent. Also reported in pepper are methyl caffeic acid piperidide and an optically active β-methyl pyrroline. There are indications that black pepper may contain a series of vinyl homologues of piperine and their stereoisomers (Thorpe, IX, 278–79; Wehmer, suppl., 161; U.S.D., 1955, 1799; Manske & Holmes, I, 168, 170; Spring & Stark, *J. chem. Soc.*, 1950, 1177; Genest *et al., J. agric. Fd Chem.*, 1963, **11,** 508; Labruyere, ibid., 1966, **14,** 469).

Piperine is stated to occur in pepper in amounts usually ranging from 4 to 10 per cent, but this amount represents crude piperine, the content of true piperine being lower. Among the methods described in literature, spectrophotometric method gives the best results for the quantitative estimation of piperine. Recently, a new procedure, based upon alkaline hydrolysis followed by titration of the liberated piperidine after distillation with water, has been suggested which gives a measure of the total pungency of pepper and its products (U.S.D., 1955, 1799; Thorpe, IV, 279; Fagen *et al., J. agric. Fd Chem.*, 1955, **3,** 860; Labruyere, loc. cit.).

Piperine was formerly official in U.S.P., but it has no marked physiological action and is no longer used in medicine. It possesses some feeble antiperiodic property. Piperine has been used to impart a pungent taste to brandy. It has also been tried as an insecticide. It is stated to be more toxic to houseflies than pyrethrum, and a mixture of 0.05 per cent piperine and 0.01 per cent pyrethrins is more toxic than 0.10 per cent pyrethrins alone (Henry, 1–2; U.S.D., 1955, 1800; Merck Index, 823).

Oil of Pepper—The characteristic aromatic odour of pepper is due to the presence of a volatile oil in the cells of the pericarp. On steam distillation, crushed black pepper yields 1.0 2.6 per cent (up to 4.8%) of the oil, the yield depending greatly upon the age of the dried fruits subjected to distillation. For the production of the oil, the lower priced qualities of pepper, damaged or broken fruits, and pepper hulls (obtained as a by-product in the preparation of white pepper) serve as economic raw material. They are distilled as fresh as possible to avoid loss of the oil during storage. White pepper is seldom used for commercial distillation since it is costly and also the hulls where the oil is mostly concentrated get removed during its preparation; the oil content in a fresh sample of white pepper is *c.* 0.95 per cent. Practically all the pepper oil offered in the market is produced in Europe or America from imported fruits. The pepper powder left after extraction of the oil can be employed for culinary purposes and also for extracting the oleoresin with alcohol [U.S.D., 1955, 1800; Guenther, V, 139–41; Malik &

Bhattacharya, *Agric. Marketing*, 1964-65, **7**(4), 3; *Chem. Abstr.*, 1940, **34**, 4828; Abraham, *Farm Bull.*, No. 55, 1959].

Oil of pepper is an almost colourless to slightly greenish liquid with a characteristic odour of pepper and also of phellandrene. The oil has a mild but not pungent taste, and has the following ranges of values: sp. gr.$^{15°}$, 0.873–0.916; $[\alpha]$, $-10°$ to $+3°$; $n^{20°}$, 1.480–1.499; acid val., up to 1.1; ester val., 0.5–6.5; ester val. after acetylation, 12–22.4; sol. in 10–15 vol. of 90% alcohol and 3–10 vol. of 95% alcohol (Guenther, V, 141–42; Gildemeister & Hoffmann, IV, 512–14).

Pepper siftings and dust (refuse obtained during the drying of pepper) are also sometimes distilled to yield inferior oils having harsher and coarser odour and flavour than those from sound fruits. Siftings gave 1.14 per cent and dust 0.85 per cent of the oil having the following characteristics, respectively: sp. gr.$^{15°}$, 0.911, 0.911; $[\alpha]_D$, $-1.3°$, $-2°$; $n^{20°}$, 1.4961, 1.4980; sap. val., 7.5, 2.8; phellandrene test negative in both the cases (Guenther, V, 142).

Oil of pepper consists chiefly of the terpenes, *l*-phellandrene, caryophyllene, and perhaps dipentene. The characteristic odour of the oil has been attributed to the presence of small amounts of oxygenated compounds (*c.* 5% in the oil) among which piperonal, dihydrocarveol, caryophyllene oxide, cryptone ($C_9H_{14}O$, b.p. 108–24°) and an alcohol ($C_{10}H_{18}O$) have been identified. A sample of the oil from Malabar black pepper (yield, 3.2%) had the following composition: α-pinene, 14; β-pinene, 23; *dl*-limonene, 25; 1-α-phellandrene, 7; caryophyllene, 19; and dihydrocarveol, 2%; epoxydihydrocaryophyllene, piperonal, cryptone, phenylacetic acid, piperidine, citronellol and other oxygenated compounds (perhaps terpenic alcohols and glycols) were found in minor quantities. In another sample, phellandrene was absent. A recent investigation has shown the presence of a number of sesquiterpenes in the oil (Guenther, V, 143; Hasselstrom *et al.*, *J. agric. Fd Chem.*, 1957, **5**, 53; Muller & Jennings, ibid., 1967, **15**, 762; Wrolstad, *J. Fd Sci.*, 1961, **26**, 499).

Oil of pepper is occasionally adulterated with the lower priced phellandrene, dipentene and caryophyllene which are natural components of the oil itself. Their presence can be detected by careful odour and flavour tests (Guenther, V, 143).

Oil of pepper is a valuable adjunct in the flavouring of sausages, canned meats, soups, table sauces and certain beverages and liqueurs. It is used in perfumery, particularly in bouquets of the oriental type to which it imparts spicy notes difficult to identify. The oil is also used in carnation compound for soaps. It finds use in medicine. A mixture of the volatile oil and resin, prepared by extracting pepper with ether was formerly official in U.S.P. Oils of black and white pepper appear to contain growth stimulants for yeasts (Guenther, V, 144; Jacobs, II, 1748; Poucher, I, 333; Snell & Snell, 561; Webb & Tanner, *Food Res.*, 1945, **10**, 273).

Pepper hulls—Pepper hulls or shells removed during the preparation of white pepper are sold separately as a light to dark brown powder with a very pungent odour and taste, and has been found useful for flavouring tinned foods. They contain: moisture, 7.0–11.0; total nitrogen, 1.72–2.36; volatile ether extr., 0.68–1.11; non-volatile ether extr., 1.51–4.97; fibre, 21.06–32.15; starch, 2.3–15.3; total ash, 7.82–28.81; and acid insol. ash, 0.79–22.90%. They are reported to contain considerable oleoresin but no piperine. The colouring matter in the shells is a pyrogallol derivative. Ground shells are used as an adulterant of ground pepper. Pepper shells are rich in volatile oil and can be used as a source of pepper oil. A sample of oil obtained from shells contained α- and β-pinenes, α-phellandrene, limonene, caryophyllene, piperonal, dihydrocarveol, and an unidentified ketone (m.p. 172°) (U.S.D., 1955, 1799; Thorpe, IX, 278; Wehmer, I, 193; Guenther, V, 140; Sharma *et al.*, *Parfum. u. Kosmetik*, 1962, **43**, 505).

Pepper by-products—Three different by-products are available in the market, viz. the pepper rejections or waste, *varagu* or the unfertilized buds, and the stems and inflorescence stalks. Analysis of these products is given in Table 10. *Varagu* and stalks are poor in ether soluble fractions and have a high content of crude fibre. Pepper rejections, however, are rich in the bite factor and can be used for preparation of the oleoresin (Dwarakanath *et al.*, *Food Sci.*, 1959, **8**, 351).

In order to economize the use of pepper as a condiment and replace it in times of scarcity, many products having the characteristic taste and pungency of pepper have been prepared by patented processes, particularly in U.S.A. A liquid pepper composition containing piperine in a concentrated form has been prepared by extracting the pepper fruits with acetone and subsequent treatment with anhydrous lactic acid. Fruits of low specific gravity but rich in oleoresin have been extracted with solvents for further processing into spice pastes. A homogeneous

TABLE 10—ANALYSIS OF TRADE GRADES AND BY-PRODUCTS OF PEPPER*

	Moisture %	Total N %	Nitrogen in non-volatile ether extr. %	Non-volatile ether extr. %	Volatile ether extr. %	Alcohol extr. %	Starch %	Total ash %	Crude piperine† %
Trade grades									
Tellicherry black pepper, garbled special bold	9.57	2.00	3.16	6.17	1.24	7.46	47.25	4.55	4.04
Tellicherry black pepper, garbled F.A.Q.	9.88	1.98	3.55	7.00	1.02	8.28	45.00	4.35	5.06
Malabar black pepper, garbled F.A.Q.	11.20	1.85	3.49	8.53	2.32	9.88	43.65	4.83	6.08
Malabar black pepper, ungarbled	10.30	1.89	3.58	9.87	1.74	11.52	40.95	4.93	7.26
Malayan black pepper	10.74	1.84	3.92	7.67	1.02	8.42	48.15	3.60	6.11
Malayan white pepper	12.27	1.76	3.72	8.09	0.03	8.72	59.40	1.06	6.10
Indian white pepper	10.60	2.01	3.83	7.35	0.51	7.22	56.25	2.79	5.72
Trade wastes and by-products									
Pepper stems and inflorescence stalks	9.15	1.94	2.72	4.21	0.48	6.18	16.94	9.37	2.31
Pepper rejections	11.31	2.15	3.38	12.44	2.00	13.36	21.15	8.02	8.58
Varagu (unfertilized buds)	9.30	2.19	1.51	2.34	0.28	4.26	14.40	13.07	0.70

* Dwarakanath *et al.*, *Food Sci.*, 1959, **8**, 351.
† Piperine content calculated using the formula, 'N in non-volatile ether extr. calculated on the original material × 20.36'.

solution of the oleoresin (containing *c.* 50% of piperine and resins, and 50% of essential oil) has been prepared for use in salad dressings (*Chem. Abstr.*, 1954, **48**, 10258; 1955, **49**, 13552; 1957, **51**, 6040).

A patent has been taken out for the preparation of a new flavouring substance named Pepper-sal from waste black pepper (rejections) and common salt. Pepper-sal has found acceptance as a flavouring agent for salads, drinks and meat dishes (Rao *et al.*, Indian Pat., No. 67931, 1959; Srinivasan *et al.*, *Food Sci.*, 1959, **8**, 289).

Mouldy and insect-infested pepper are in no way inferior to good quality pepper in their ether and alcoholic extract contents. Mouldy pepper, having suffered no damage in the chemical constituents, can be reclaimed by removing fungal growth. A sample of mouldy pepper from a Cochin godown contained: moisture, 12.02; total nitrogen, 2.06; non-volatile ether extr., 6.56; volatile oil, 0.73; alcohol extr., 9.70; starch, 43.65; crude fibre, 15.12; and ash, 5.05%. Insect-infested pepper, however, consists of hollow berries and is low in starch. It contains: moisture, 10.97; total nitrogen, 2.18; non-volatile ether extr., 7.89; volatile oil, 0.52; alcohol extr., 11.04; starch, 40.95; fibre, 15.78; and ash, 4.35%. It can be used with other by-products for the preparation of the oleoresin of pepper (Dwarakanath *et al.*, *Food Sci.*, 1959, **8**, 351).

Production and Trade

Production—The average annual production of pepper in India ranges between 23,000 and 28,000 tonnes (Table 9). Though the price of pepper has gone up since World War II, there is no appreciable increase in acreage or production in India. The main reason for this is the wide fluctuation prevailing in the price of pepper from year to year; the cultivators do not feel confident that the prices will continue to be remunerative when the crop, which takes four to five years to come into full bearing, reaches the market (*Rep. Spices Enquiry Comm.*, 1953, 17; *Export Prospects of Pepper*, 1965, 29).

Assembling and Marketing—As the pepper producing areas in India are mainly concentrated in the foot-hills of the western ghats, the important interior assembling markets are confined to Kerala and South Kanara. Assembling markets in Kerala are: Palai, Kottayam, Thodupuzha, Muvathupuzha, Parkunnam, Wynaad and Iritty, while in South Kanara, the major market is Kangangad. Important

distributing markets are on the coast, viz. Alleppey, Cochin, Calicut, Tellicherry, Baliapatnam and Mangalore. The produce is carried to the interior assembling markets, mostly as headloads by the cultivators in small lots of 2.5–5.0 kg., from whom the village merchant purchases the produce and transports it when he has accumulated a sizeable quantity of about 300 kg., to the assembling markets on the coast. There the produce is delivered to the commission agents, who supply it to the shippers and exporters. The latter get the produce garbled, and graded and packed for supply to foreign or inland markets. In India, garbling is done partially by hand and partially by machines. By greater mechanization, the cost of garbling can be reduced (*Rep. Spices Enquiry Comm.*, 1953, 26–27).

Grades and Specifications—Black pepper meant for export from India is graded under Agmark, the specifications covering more or less all qualities of the produce, viz. whole and heavy fruits, light fruits and pinheads (under-developed or broken fruits). Grade designations of whole black pepper along with their Indian Standards requirements are given in Table 11. Though numerous types of pepper are grown in India, in trade only two groups are mainly valued, viz. Malabar and Tellicherry peppers, each further classified under two grades, garbled and ungarbled. Garbled pepper contains less than 3 per cent impurities while ungarbled pepper contains 3–7 per cent impurities. Standards have also been drawn up for ground black pepper, though no exports are made from India. Pepper intended for exports should be graded and marketed under the Pepper Grading and Marketing Rules and should be certified by the Spices Export Promotion Council which is authorized to test samples for quality and fix their grades and Agmark labels [Malik & Bhattacharya, *Agric. Marketing*, 1964–65, 7(4), 3; IS: 1798-1961].

Among the different grades recognized in world trade, the Tellicherry and Alleppey black pepper are considered valuable for their large size, dark reddish brown colour and excellent aroma. The average weight per hundred fruits and per litre of the different grades of black pepper in world trade are as follows: Mangalore, 8.57, 574; Malabar, 5.74, 570; Singapore, 4.89, 476; Lampong, 3.59, 511; and Acheen (Sumatra), 3.10–3.44, 330–432 g. Among the white pepper of commerce, the most important is Muntock white pepper from Banka Islands and to a lesser degree the Sarawak white pepper. Analysis of some of the trade grades of black and white pepper is presented in Table 10 [Malik & Bhattacharya, *Agric. Marketing*, 1964–65, 7(4), 3; Guenther, V, 139–40; Winton & Winton, IV, 328–29].

Since the quality of pepper depends upon the content of the active principles in it, pepper has to

TABLE 11—INDIAN TRADE DESIGNATIONS OF WHOLE BLACK PEPPER AND THEIR REQUIREMENTS*

Grade designation with abbreviation (1)	Moisture %, max. (2)	Pinheads %, max. (3)	Light fruits %, max. (4)	Extraneous matter %, max. (5)	Special characteristics (6)
Garbled Malabar:					
MG 1	11.0	nil	2.0	0.5	Grown in S. India; garbled by cleaning or winnowing; black in colour; nearly globular with a wrinkled surface, the deepest wrinkles forming a network in the dried fruit
MG 2	11.0	nil	3.0	0.5	
Ungarbled Malabar:					
MUG 1	12.0	1.0†	7.0	2.0†	Grown in S. India; colour varying from brown to black; with a wrinkled surface
MUG 2	12.0	1.0†	10.0	2.0†	
Garbled Light:					
GL 1	12.0	1.5†	..	1.5†	Grown in S. India; colour varying from dark brown to black; garbled, consisting of light fruits
GL 2	12.0	4.0‡	..	2.0‡	
Non-specified: NS	12.0	3.0‡	..	2.0‡	Mixture of fruits of different grades in varying proportions
Pinheads: PH	12.0	..	..	3.0	

* IS: 1798-1961.
† The total of the 2 values under columns (3) and (5) shall not be more than 2%. ‡ The total of the 2 values under columns (3) and (5) shall not be more than 4%.

conform to the food specifications of the importing countries. Commonwealth food specifications for black pepper are: ether extr., $\nless 6$: absolute alcohol extr., $\nless 8$; total ash, $\ngtr 7$; and ash insol. in HCl, $\ngtr 1.5$%. The U.S. Government requirements for black and white pepper are respectively as follows: non-volatile ether extr., $\nless 6.75$, $\nless 7.00$: starch, $\nless 30$, $\nless 52$; total ash, $\ngtr 7$, $\ngtr 3.5$; and acid insol. ash, $\ngtr 1.5$; $\ngtr 0.3$% (Dwarakanath *et al.*, *Food Sci.*, 1958, **7**, 285 ; Parry, J.W., 1962, 206).

Light pepper, containing the comparatively lighter fruits and pinheads are comparable to sound and plump fruits in their nitrogenous and volatile oil contents. A sample of pinheads from Alleppey contained: extraneous matter, 28.97 : moisture, 11.1 ; protein, 9.12 ; starch, 31.18 ; fibre, 17.60 ; non-volatile ether extr., 5.5 : volatile oil, 1.6 ; and ash, 10.88% ; wt./litre, 366.6 g. Light pepper and pinheads though looked down upon in trade can be made use of for the manufacture of ground pepper (Malik & Bhattacharya, loc. cit.).

Whole black pepper is often adulterated with the fruits of *Lantana camara*, *Vitex altissima* Linn. f., or with the seeds of *Carica papaya*, and the dried and roasted berries of *Schinus molle* Linn. Addition of dried papaya seeds can be detected by the fact that the product will have a lower crude starch and higher non-volatile ether extract content than true pepper [Allen, VII, 172–74, 181–84 ; *Rep. Spices Enquiry Comm.*, 1953, 21 : Bhatnagar & Gupta, *Res. Bull. Panjab Univ., N.S., Sci. Sec.*, 1965, **16**(4), 323 ; Thorpe, IX, 279–80 ; Mitra & Roy, *J. Instn Chem. India*, 1955, **27**, 100].

Exports—India has been a chief source of pepper to world markets since time immemorial. At present Indonesia, India and Sarawak are the three leading exporters of pepper accounting for *c.* 97 per cent of world exports ; Cambodia, Ceylon, Malagasy and Brazil account for the balance. India's share in exports has been declining in recent years, mainly due to the increased supplies from Indonesia and Sarawak and the development of pepper plantations in Malagasy and Brazil (*Export Prospects of Pepper*, 1965, 9).

The main market for Indian pepper has been U.S.A. Immediately after the war, the total exports from India to U.S.A. increased from 873 to 11,000 tonnes. About 60 per cent of the American demand is met by Indian exports. In recent years, U.S.S.R. has become the second largest market for Indian pepper and its share has trebled (from 6 to about 19%). At present U.S.S.R. and the East European countries together account for a bigger share for Indian pepper than U.S.A. ; in recent years U.S.A. has been importing its requirements mainly from Indonesia and Brazil. Other countries which show preference to Indian pepper are, West Germany, France, Italy, Netherlands, Belgium, U.K. and Canada. The exports of pepper to different countries are given in Table 12 [*Export Prospects of Pepper*, 1965, 11, 32–45 ; Kevorkian, *Foreign Agric.*, 1965, **3**(29), 11].

India has not been able to establish herself well in the European markets in general, because the demand is mainly for white pepper in these countries. Even in such countries as Greece, Norway and Spain, where black pepper is in demand, India has not been able to make much headway due to serious competition from Indonesia and Sarawak (*Export Prospects of Pepper*, 1965, 46–47).

Cochin, Alleppey, Bombay, Calicut and Mangalore are the major ports from where black pepper is exported from India. For export purposes, pepper is generally packed in double gunny bags, with a capacity of 60–75 kg. The outer bag is new, while the inner one is usually old. Indian Standards require that unless agreed to otherwise between the purchaser and the vendor, black pepper, whole, shall be packed in clean and sound jute bags, with or without a moisture-proof lining of a material which does not impart any foreign smell to the product. The mouth of each bag shall either be machine-stitched or rolled over and hand-stitched. It has been found that pepper dried and immediately packed in double burlap bags with a polythene or alkathene lining is free from infestation from insects and fungi for a long time [*Rep. Spices Enquiry Comm.*, 1953, 21 ; IS: 1798–1961 ; Abraham, *Cashew & Pepper Bull.*, 1957–58, **2**(5), 3].

Internal Trade—Internal consumption of pepper in India is fairly large but in recent years, it has shown a downward trend due to major portion being exported outside and higher prices prevailing inside the country. The quality of the spice distributed in the internal markets has also become poor, consisting of a large proportion of hollow and light berries and a considerable amount of foreign matter. In internal trade, the produce is moved mostly by means of coastal steamers and the bulk of the produce is transferred from Alleppey and Cochin. Formerly, half the quantity entering internal trade used to be moved to Bombay and the other half to Calcutta, these two

TABLE 12—EXPORTS OF BLACK PEPPER FROM INDIA TO DIFFERENT COUNTRIES

Countries	Qty (in thousand kg.)						Val. (in thousand Rs.)					
	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67
U.S.S.R.	2,781	2,962	5,634	5,000	8,029	3,274	10,270	9,340	17,876	20,069	34,140	17,423
U.S.A.	8,961	6,470	2,332	2,258	5,760	3,385	32,670	19,975	6,987	9,577	24,355	19,961
Italy	1,612	1,786	1,760	1,589	1,861	1,731	6,530	5,947	5,693	6,284	8,395	10,490
Yugoslavia	706	597	479	740	1,182	1,292	2,763	1,914	1,584	2,744	5,079	7,767
Czechoslovakia	455	814	810	706	1,053	530	1,898	2,734	2,596	2,847	4,557	3,281
Canada	1,128	1,339	1,179	974	1,138	995	4,148	4,094	3,624	3,704	4,730	6,147
U.A.R.	..	..	768	275	919	245	..	..	2,378	1,245	3,848	1,308
Poland	557	707	840	790	838	710	2,206	2,304	2,701	2,980	3,576	4,135
Hungary	495	517	380	515	780	650	1,948	1,658	1,231	2,036	3,371	3,465
E. Germany	581	1,165	1,295	920	480	702	2,316	3,844	4,039	3,611	2,097	3,879
Rumania	621	117	345	495	440	1,035	2,587	397	1,115	1,895	1,833	5,901
Algeria	25	..	4	290	150	475	101	..	12	1,211	666	2,722
W. Pakistan	134	366	413	447	152	..	723	1,249	1,283	1,444	577	..
E. Pakistan	127	258	156	189	46	..	633	968	570	769	202	..
Bulgaria	123	277	100	235	100	155	486	893	320	920	432	932
France	253	334	50	108	..	48	917	998	134	446	..	258
Other countries	3,060	3,159	2,389	1,157	2,187	1,793	10,672	9,391	6,742	4,094	8,991	10,698
TOTAL	21,619	20,868	18,934	16,688	25,115	17,020	80,868	65,706	58,885	64,155	106,849	98,367

acting as important distributing markets for northern India. In recent years, Calcutta has become the main distributing centre for North India, while Bombay mainly deals with re-exports to the foreign markets. Besides coastal steamers, part of the pepper going to the North Indian markets is transported by rail. Cochin and Tellicherry are the main stations for rail exports. From there pepper is despatched to Madras, Bangalore, Bombay, Delhi, Kanpur and Calcutta. From Calcutta, the subsequent distribution is mainly done by rail (*Export Prospects of Pepper*, 1965, 17; *Rep. Spices Enquiry Comm.*, 1953, 23–24).

Prices—The average annual price of pepper at Cochin was Rs. 108 for 300 kg. in 1939. By about 1948, it reached up to Rs. 690 and in 1949, the price suddenly shot up to Rs. 2,286 and increased still further in the subsequent years. The price of pepper has been fluctuating very widely in the world market from year to year and has made the production and trade of pepper very uncertain and risky. Factors influencing these fluctuations are in most cases unforeseeable developments such as weather, pests, etc., sometimes amplified by speculative influences such as cornering of stocks. Efforts have been made to stabilize the price by consultation amongst producing countries, namely India, Indonesia, Sarawak and Cambodia, but so far no concrete proposal has been formulated or accepted. Attempts to limit the effect of fluctuations or production have been made by Ceylon, where co-operatives purchase pepper at a price fixed by the government (*Export Prospects of Pepper*, 1965, 57; *FAO, Commodities Bull. Ser.*, No. 34, 1962, 26).

P. peepuloides Roxb.
Fl. Br. Ind., V, 83.

A slender, glabrous climber or an erect shrub about 3 m. in height, found in tropical Himalayas from Nepal to Bhutan, and in Assam, Lushai hills and Khasi hills ascending to a height of 900 m. Leaves 5.0–12.5 cm. long and 2.5–5.0 cm. wide, ovate oblong, acuminate, sometimes narrowed to a minutely cordate base; petiole 0.25–0.50 cm. long; male spikes slender, 5.0–7.5 cm. long, clothed with peltate bracts; female spikes 1.25–2.5 cm. long, cylindric; fruit 2 mm. in diameter, not very firmly held on the axis.

The fruiting spikes are sold as long pepper (*Savali peepul*). They are mostly collected from wild plants

in Assam. The fruits which mature from autumn to winter months are collected by villagers and brought to Shillong in small lots to the wholesale dealers. The total production is estimated at about 80,000 kg. per annum. It is sold either pure or adulterated with the spikes of *P. longum*. The fruits have no pungency when chewed, but exhibit strong sialogogue action, followed by numbness and tingling sensation on the tongue. They contain a liquid alkaloid, but no piperine. Recently, the presence of an unusual lignan (+)-diaeudesmin ($C_{22}H_{26}O_6$, m.p. 157–58°) and a substance named pipataline ($C_{19}H_{28}O_2$, m.p. 38°) has been reported in the fruits. Petroleum ether extract of the fruits, when administered parenterally produced marked convulsion in experimental animals (Atal & Ojha, *Econ. Bot.*, 1965, **19**, 157 ; Atal *et al.*, *J. chem. Soc.*, *Ser. C.*, 1967, 2228 ; *Chem. & Ind.*, 1967, 2173 : Chandhoke & Ghatak, *Indian J. exp. Biol.*, 1968, **6**, 33).

The stem and the roots are used as medicine in leprosy in the Khasi and Jaintia hills (Fl. Assam, IV, 34).

P. retrofractum Vahl syn. *P. chaba* Hunter non Blume, *P. officinarum* DC. JAVA LONG PEPPER

D.E.P., VI(1), 256 ; C.P., 890 ; Fl. Br. Ind., V, 84; Kirt. & Basu, III, 2130, Pl. 822.

HINDI—*Chab, chavi* ; BENG.—*Chai, choi, gachha* ; MAR.—*Chavala, miravela* ; GUJ.—*Chavaka* ; TEL.—*Chaikama, sevasu*.

A glabrous rather fleshy climber, with adhesive roots, native of the Moluccas, reported to be cultivated in India and Indonesia. Leaves oblong, ovate or lanceolate, acuminate, base rounded, unequal, 12.5–18.0 cm. long, 6.0–7.0 cm. wide, petioles 6.0–13.0 mm. long ; fruiting spikes cylindro-conic ; fruits very small, bright red, globose, 2.0–2.5 mm. diam.

This species furnishes the Java Long Pepper, which is the chief commercial long pepper exported from Indonesia to various countries. The fruiting spikes of this species are also imported into India mainly from Singapore and they are reported to be cheaper than other long peppers, and measure 2.5–4.0 cm. long and 5.0–8.0 mm. in diameter : they are reddish brown with a comparatively smooth surface (Atal & Ojha, *Econ. Bot.*, 1965, **19**, 157 ; Kirt. & Basu, III, 2130; Burkill, II, 1742, 1752).

The fruits have a weak aromatic odour and a pungent flavour somewhat resembling black pepper, but weaker and less agreeable, producing a ginger-like after taste ; their smell becomes objectionable on warming. They are used as a spice and in pickles and preserves. They are not marketed in the ground form ; their flavour and smell on warming preclude their use in an unmixed state. Sometimes, ground long pepper is used as adulterant of ground black and white pepper, for which purpose it may be bleached. When added to pepper in considerable amounts, it imparts a peculiar slaty colour and a characteristic odour on warming ; it also causes an increase in acid-insoluble ash. It can be easily identified under the microscope by its well defined and angular starch granules which are much larger in size (6–10μ) than those of ordinary pepper and appear isolated or loosely clustered (Thorpe, IX, 280 : Atal & Ojha, loc. cit. ; Allen, VII, 181–83 ; Hill, 452).

Java long pepper is similar in composition to black pepper ; it contains less piperine and volatile oil. Analysis of a sample of long pepper gave the following values : moisture, 9.5 ; protein, 12.2 ; piperine, 4.5 ; fixed oil, 6.6 ; volatile oil, 1.5 ; starch, 39.5 ; fibre, 5.8 ; total ash, 5.9 ; acid sol. ash, 4.2 ; and sand, 0.2%. A pellitorine-like alkaloid has been reported in the fruits. Dried long pepper yields on steam distillation about 1 per cent of a light green, viscous, volatile oil, with an odour reminiscent of that of black pepper and ginger oil. The oil is not produced commercially (Winton & Winton, IV, 337, 330 ; Atal & Ojha, loc. cit. ; Guenther, V, 147).

The fruits have stimulant and carminative properties and are used in haemorrhoidal affections. In Malaya, they are used in tonics for languidness and after childbirth and also in digestive and other disorders. The stem has properties similar to *pipla-mul* or *pipli* from *P. longum* and is used in medicine as a substitute for the same. It contains the alkaloids piperine and piplartine : β-sitosterol, glycosides, mucilage, and glucose and fructose have also been reported. Preliminary pharmacological experiments indicate the presence of a smooth muscle-relaxant active principle in the stem (Bose, *Sci. & Cult.*, 1935–36, **1**, 111 ; Mishra & Tewari, *J. pharm. Sci.*, 1964, **53**, 1423 ; Miglani & Gupta, *J. Instn Chem. India*, 1964, **36**, 259 ; Tewari *et al.*, *Labdev. J. Sci. & Technol.*, 1964, **2**, 118 ; Atal & Ojha, loc. cit.).

In the Philippines, roots are chewed or brewed in decoction as a cure for colic ; they are also used for dyspepsia and gastralgia. The wood and root are reported to have been used in Bengal for dyeing ; they give a pale brown colour on cotton if used alone and a brownish red when mixed with *Caesalpinia sappan* (Quisumbing, 217).

Fruits available in trade under the name *Gaj Pipal* are erroneously supposed to be from this species. They have been shown to be the inflorescence of *Borassus flabellifer* and *Syndapsis officinalis*. Similarly some characteristically twisted and dried stems are sold as *Chavak* and supposed to be stems of this species. They have been definitely proved to be not of any *Piper* species (Atal & Ojha, loc. cit.).

Among the other species of *Piper* occurring in India, the undermentioned are reported to be used as substitutes for *P. betle*, *P. nigrum* or *P. longum*.

P. bantamense Blume syn. *P. attenuatum* Buch.-Ham. ex Miq., a slender, rambling climber, with stout but soft, flexuous branches, is found in the eastern tropical Himalayas, Assam, Khasi hills, Orissa, hills of Vishakhapatnam and Godavari districts (at 600–900 m.), the eastern slopes of Nilgiris, the western ghats, and the hills of Tirunelveli district. It bears orbicular-ovate or cordate leaves, 6.0–15.0 cm. long and slender female spikes, lengthening in fruit to 23 cm. The fruits are ellipsoid or globose, 4 mm. in diameter.

In Malaysia, parts of this plant are put into water when washing clothes in order to scent them. It has an intense rubefacient effect and is used in poultices for headache and other pains. The root macerated in water is said to be used as an excellent diuretic (Burkill, II, 1736; Kirt. & Basu, III, 2136).

P. hamiltonii C. DC. (*Jangli Pan*), a glabrous shrubby, scandent plant, with coriaceous elliptic or almost rounded leaves, found in Sikkim Terai, West Bengal and in Khasi hills, is reported to be one of the wild peppers of India.

P. mullesus Buch.-Ham. syn. *P. brachystachyum* Wall. ex Hook. f. (*Pahari pipar, pahari pan*), is a glabrous shrub found in the sub-tropical Himalayas, from Simla to Bhutan up to a height of 1,500 m., in the Khasi hills and in the Nilgiris. It bears thinly coriaceous leaves, 7.5–17.5 cm. long, and globose or shortly oblong fruiting spikes. The reported chemical composition of leaves of a wild growing pepper probably refers to this species. The leaves on steam distillation gave a volatile oil with an odour reminiscent of lime oil and having the following characteristics: sp. gr.$^{30°}_{30°}$, 0.9035; $n^{30°}$, 1.4969; acid val., 1.2; ester val., 12.4; and ester val. after acetylation, 37.9 (Sanjiva Rao *et al., Perfum. essent. Oil Rec.*, 1937, **28,** 87).

P. schmidtii Hook. f. (NILGIRI PEPPER) is a large climbing shrub found in Assam, western ghats, the Nilgiri and Palni hills above 1,500 m., especially in the shola forests. It bears ovate-elliptic leaves and long, curved and spirally twisted fruiting spikes with red or yellow, fleshy fruits, oblong or globose. It is another wild pepper reported to be used as spice or condiment among the indigenous population of the Nilgiris. This is sometimes referred to as Big Berry and is reported to be present among cultivated plants in some estates (Barber, *Bull. Dep. Agric. Madras*, No. 56, 1909, 128; Krishnamurthi, 174).

P. subpeltatum Willd. = *Pothomorphe subpeltata* (Willd.) Miq. syn. *Heckeria subpeltata* Kunth is a large herbaceous shrub found in the western ghats in all districts in evergreen forests up to 1,500 m. It bears coarse, orbicular leaves and cylindrical spikes 12–15 cm. long. The leaves are eaten raw or cooked as a seasoning and the sweet fruits are also eaten. In the Philippines, young leaves and flowers are boiled with fish for flavouring. In Malaya, the leaves are used for poulticing. In the Moluccas they are applied to wounds and swellings. A decoction is taken internally for distended stomach (Burkill, II, 1953–54; Brown, 1941, I, 446).

P. sylvaticum Roxb. (BENG. & ASSAM—*Pahari-pipul*), a low creeping, succulent plant is found in the jhils and lower hills of Bengal and Assam and is said to resemble *P. bantamense* and *P. longum*. It yields fruits (3–4 mm. in diam.) used both in the green and ripe condition in food preparations. In Bengal, the fruits are used as carminative (Kirt. & Basu, III, 2131).

P. thomsoni Hook. f. (SIKKIM—*Pipla, jungli pan*), a scandent, glabrous climber with ovate-oblong or lanceolate acuminate leaves, is very common and abundant in Sikkim, up to an altitude of 2,100 m. and in Bengal, Khasi and Jaintia hills and in Manipur. Its leaves are used as *pan* in Sikkim and the roots are macerated in water and used as a diuretic (*Bull. bot. Surv. India*, 1960, **2,** 244; Rao Rolla, ibid., 1963, **5,** 175).

P. trichostachyon DC., a woody, stout-stemmed vine, with elliptic-lanceolate leaves is found in the western ghats up to 750 m. in Mysore and Kerala and Sivagiri hills in Tirunelveli district. It is reported as occurring along with cultivated pepper in some estates in Malabar. It is also called Ponched Pepper and has characteristically fragrant spikes and large fruits (Barber, *Bull. Dep. Agric. Madras*, No. 56, 1909, 128).

P. wallichii Hand.-Mazz. syn. *P. aurantiacum* Wall. ex DC.; *P. arcuatum* Blume (HINDI—*Shambhaluka*

bui; Beng.—*Renuk*), a stout glabrous climber, with coriaceous leaves, 7.5–10.0 cm. long, is found in Nepal, Lakhimpur and the Khasi hills in Assam. It bears drooping spikes, 3.8–7.5 cm. long, with fruits distinctly angular and pyramidal when young, and globose when ripe, about 4 mm. in diameter.

The fruits are reported to possess bitter, acrid and cooling properties. They are reported to be used as uterine stimulant. Crude alcohol extract of fruits (from Jaipur market), when injected into dogs showed some hypotensive activity and strong stimulation of the uterus and intestines, increasing both tonus and movement. The fruits probably contain maltose, but no alkaloids (Kirt. & Basu, III, 2136; Arora *et al.*, *Univ. Rajputana Stud.*, *Med. Sec.*, 1953–54, 30).

PIPTADENIA Benth. (*Leguminosae*; *Mimosaceae*)

Fl. Br. Ind., II, 289.

A genus of trees and shrubs distributed in the tropics, chiefly in South America. One species is found in India and another has been introduced.

P. oudhensis Brandis=*Indopiptadenia oudhensis* (Brandis) Brenan (Oudh—*Genti*) is a small, handsome, prickly tree with bipinnate leaves, occurring on the outermost Himalayan foot-hills of Uttar Pradesh; it is also occasionally cultivated in gardens in North India and West Bengal. The tree is reported to be lopped for cattle fodder. The wood is hard, close-grained and durable (Parker, 201; Brandis, 1874, 169; Gamble, 289).

P. rigida Benth.=*Parapiptadenia rigida* (Benth.) Brenan, a native of Brazil, is a shrub or a tree with bipinnate leaves and axillary spikes of small white flowers, introduced in F.R.I. Arboretum, Dehra Dun, and is reported to be growing well. In Brazil, it is one of the chief sources of Angico Gum which sometimes occurs in commerce as amber coloured, water-soluble, angular or globular fragments (5.0–7.5 cm. in diam.) and resembles gum arabic in general properties. The gum is used as an adhesive and as a constituent of medicines. The bark contains tannins (15–20%) and colouring matter and is used for tanning. The wood is reddish brown, very hard and heavy (wt., 945 kg./cu.m.) and is used for construction purposes. It is also reported to be a source of paper pulp. Analysis of the wood gave the following values: cellulose, 41.30; lignin, 26.50; pentosans, 21.00; and ash, 0.90% (Raizada & Hingorani, 24; Howes, 1949, 61; Mantell, 71; *Econ. Bot.*, 1953, **7**, 189; Record & Hess, 307; *Chem. Abstr.*, 1957, **51**, 17165).

PIPTURUS Wedd. (*Urticaceae*)

Fl. Br. Ind., V, 589.

A small genus of trees or shrubs found from Mascarene Islands to Malaya, Australia and Polynesia. One species occurs in India.

P. incanus Wedd. syn. *P. velutinus* Wedd. is a tree or shrub with ovate-cordate leaves (10–20 cm. in diam.) and axillary spikes of small flowers found in the Andaman and Nicobar Islands. The leaves are employed for poulticing boils, burns and herpes; they are also used in gargles for thrush. Bark yields a fibre used for sails and nets (Burkill, II, 1754; Uphof, 284).

PISCIDIA Linn. (*Leguminosae*; *Papilionaceae*)

Bailey, 1947, III, 2648; Benthall, 148, Fig.

A small genus of evergreen trees native of tropical America. *P. piscipula* (Linn.) Sarg. syn. *P. erythrina* Linn. (Jamaica Dogwood) has been introduced into some of the Indian gardens; the trees, however, remain small and are more or less straggling in habit.

The wood of *P. piscipula* is valued for its toughness. It is used for heavy construction and as a substitute for mahogany; it is also employed for boat building, charcoal and fuel [Record & Hess, 308; Butler &

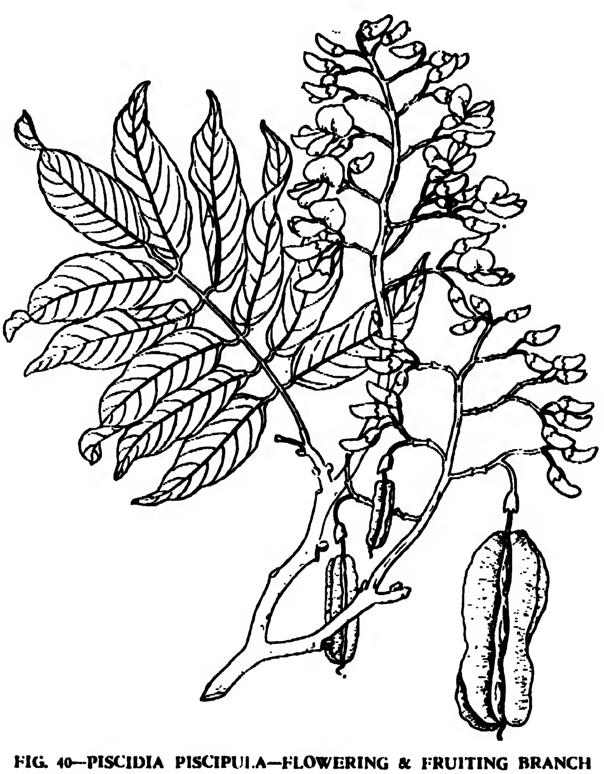


FIG. 40—PISCIDIA PISCIPULA—FLOWERING & FRUITING BRANCH

Mullen, *Acta phytother., Amst.*, 1955, **2**(8), 1 : Uphof, 284].

Almost all parts of the plant are used for stupefying fish : they have also been shown to be toxic to some species of insects (U.S.D., 1955, 1808 ; Auxence, *Econ. Bot.*, 1953, **7**, 270).

The bark possesses anodyne and sedative properties, and its extract is used in neuralgia and dysmenorrhoea. Preparations of the bark showed appreciable uterine depressant activity in experimental animals. Jamaica is the main source of the commercial bark, which is obtained as a by-product of the lumbering operations : commercial bark, therefore, mostly consists of stem bark, though root bark has been reported to be more potent (Martindale, I, 1384 ; Wren, 168 : Youngken, 476 ; Auxence, loc. cit.).

The bark has been variously reported to contain glucosides, an amorphous alkaloid, piscidic acid ($C_{11}H_{12}O_7$, m.p. 181-85°), rotenone, an unsaturated ketone named ichthynone ($C_{23}H_{20}O_7$, m.p. 202-04°), which is highly toxic to goldfish, and 5 new aromatic substances, viz. jamaicin ($C_{22}H_{18}O_6$, m.p. 193 94°), lisetin ($C_{25}H_{24}O_8$, m.p. 285°) and traces of substances designated D, E and G (m.p. 253°, 211° and 219° respectively). Jamaicin is biogenetically related to rotenoids, whereas compound G is possibly an anthoxanthin (Moore & Eng, *J. Amer. chem. Soc.*, 1956, **78**, 395 : Kapoor *et al.*, *Helv. chim. acta*, 1957, **40**, 1574 ; Stamm *et al.*, ibid., 1958, **41**, 2006).

PISONIA Linn. (*Nyctaginaceae*)

A genus of trees and shrubs distributed in the tropics. Three species occur in India.

P. aculeata Linn.

D.E.P., VI(1), 268 ; Fl. Br. Ind., IV, 711 ; Kirt. & Basu, Pl. 784.

BENG.—*Baghachura* ; TEL.—*Embudi, konki, konakaraputri, pisangi* ; TAM.—*Karindu, murukkalli, muruvilikkodi, turattumal udappu* ; KAN.—*Antuhannu gida, sulesoppu* ; ORIYA—*Hati-ankusa, hathianso*.

A large scandent shrub with recurved thorns found along the sea coasts in the peninsular India, particularly from Konkan southwards in the west and from Orissa southwards in the east, and also in the Andaman Islands. Bark light brown, thin ; leaves elliptic or elliptic-lanceolate, obtuse, entire ; flowers in axillary and terminal cymes ; fruit oblong or clavate, 5-ribbed, ribs marked with stiff glandular-headed short sticky prickles in double rows.

The plant makes an excellent hedge. The bark and leaves of the plant are used as a counter-irritant for swellings and rheumatic pains. The juice mixed with pepper and other ingredients is given to children suffering from pulmonary complaints. In Philippines, a decoction of fresh leaves is used to wash scabies. The sticky fruit is used in Philippines to trap birds, small animals and monkeys (Kirt. & Basu, III, 2049 ; Quisumbing, 277 ; Fox, *Philipp. J. Sci.*, 1952, **81**, 173).

P. grandis R. Br. syn. *P. alba* Spanoghe ; *P. sylvestris* Teijsm. & Binn. ; *P. morindaefolia* R. Br. ex Wight

LETTUCE TREE

D.E.P., VI(1), 268 ; Fl. Br. Ind., IV, 711 ; Fl. Malesiana, Ser. I, **6**(3), 464, Fig. 11, 13.

GUJ.—*Velati salet* ; TEL.—*Lanchamundaku* ; TAM.—*Lechai kottai, chandu* ; KAN.—*Sulesoppu*.

BOMBAY—*Chinai salit*.

An evergreen tree, 9-12 m. high, reported to be found in the beach forests of the Andaman and Nicobar Islands and in the Laccadive Islands. Leaves, 15–25 cm. long, ovate-oblong to oblong, pale greenish or yellowish ; flowers dioecious, in corymbose terminal cymes ; fruits narrow club-shaped, 5-angled, angles with one row of prickles.

This species is distributed mainly in small remote islands from the western Indian Ocean to the eastern Pacific. The commonly grown lettuce tree is, however, considered to be only a cultigen derived from the wild plants by repeated transplantation. This is especially adapted to sea coast and succeeds well in gardens in Madras and other places near the sea, on both east and west coasts. It is also grown as a hedge or windbreak. It is propagated by cuttings ; it produces flowers very rarely (Airy Shaw, *Kew Bull.*, 1952, 87 ; Fl. Malesiana, Ser. I, **4**, lxviii ; Firminger, 387–88 ; Fl. Madras, 1164 ; Chatterjee & Randhawa, *Indian J. Hort.*, 1952, **9**, 64).

The leaves of the cultivated plant resemble lettuce in taste and are used as vegetable and as salad ; the leaves of the male tree are darker and said to be less appetizing. The leaves are also fed to cattle. Analysis of the tender and mature leaves gave the following values respectively : moisture, 90.2, 81.7 ; protein, 3.6, 5.1 ; fat, 0.2, 0.4 ; carbohydrates, 3.2, 10.2 ; fibre, 0.6, ... ; and mineral matter, 2.2, 2.6% ; calcium, 170, 320 ; phosphorus, 60, 80 ; and iron, 3.6, 2.6 mg./100 g. Vitamin values in tender leaves are : vitamin A, 1,480 I.U. ; thiamine, 0.03 ; riboflavin, 0.11 ; nicotinic acid, 0.2 ; and vitamin C, 10 mg./100 g. (Burkill, II, 1755 ; Airy Shaw, loc. cit. ; Rama Rao,

328 : Gopalaswamiengar, 246 : Nutritive Value of Indian Foods, 55, 92, 125).

The fresh leaves, moistened with Eau-de-Cologne, are used to subdue inflammation of a filarioid nature in the legs and other parts. They are used as diuretic. The root is considered purgative (Hocking, 174).

P. umbellifera (Forst.) Seem. syn. *P. excelsa* Blume, an evergreen tree, 9–15 m. high, with obovate to elliptic or oblong-lanceolate leaves, fragrant flowers and sticky fruits, is found in the Andaman Islands. The wood of the plant is white, soft and full of sap; it is eaten with relish by elephants (Stemmerik, *Blumea*, 1963–65, **12,** 275 : Corner, I, 511 : Parkinson, 227).

Pistachio — *see* **Pistacia**

PISTACIA Linn. (*Anacardiaceae*)

A genus of dioecious trees and shrubs distributed chiefly from the Mediterranean region to East Asia, and in Mexico and Texas. Two species occur in India. Some of the species, not found in India, yield valuable articles of trade. *P. vera* Linn. is the source of Pistachio Nut (*Pista*) which is imported in considerable quantities into India. *P. lentiscus* Linn. yields Mastic, a high grade resin, which is also imported into India.

P. integerrima Stewart ex Brandis

D.E.P., VI(1), 268 ; C.P., 901 ; Fl. Br. Ind., II, 13.

N. W. HIMALAYAS—*Kakra, kakri, kangar.*

A moderate-sized deciduous tree, up to 18 m. in height and 2.7 m. in girth, with a short stout bole found in the Himalayas from Indus to Kumaun at altitudes of 350–2,400 m. : it is often cultivated in the Punjab plains. Bark dark grey or blackish, viscous and aromatic when cut; leaves pinnate: leaflets lanceolate, 7–12 cm. long; flowers in panicles, small, reddish; drupe globose, c. 6 mm. in diam., rugose, grey when ripe.

This species has been considered as a synonym or a variety of *P. khinjuk* Stocks by some earlier authors. More recently, it has been regarded as *P. chinensis* Bunge var. *integerrima* Zohary (Zohary, *Palest. J. Bot., Jerusalem Ser.*, 1950, **5,** 187).

The tree grows on hot dry slopes with shallow soil or on open rocky ground and limestone soil. In Punjab and Himachal Pradesh, it is common in *Pinus roxburghii* forests and is often associated with *Acacia modesta* and *Olea ferruginea*. Natural seedlings spring up under bushes and force their way out. The rate of growth is moderate with an annual girth increment of 1.8–2.0 cm. Shoots are reported to be affected by the pests *Chaetoptelius vestitus* Rey., *Estenoborus perrisi* Beeson and *Pemphigus aedificator* Buckton [Troup, I, 236 : Osmaston, 140 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 38].

The tree yields a beautifully mottled ornamental wood. Sapwood is white and broad ; heartwood olive-yellow to yellowish brown, striped with darker lines, straight to interlocked-grained, medium-textured, hard, strong and heavy (sp. gr., 0.883 ; wt., 881 kg./cu. m.). The wood can be seasoned with ease, but if left in the log it sometimes develops radial splits ; green conversion and stacking the planks in close piles under cover have been recommended. It is durable even in the open. It is not difficult to saw and can be worked to a smooth finish, taking a lasting polish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: weight, 130 ; strength as a beam, 80 ; stiffness as a beam, 70 ; suitability as a post, 65 ; shock resisting ability, 140 ; retention of shape, 70 ; shear, 145 ; and hardness, 130. The wood is chiefly used for ornamental work and carving, panels, inlay work, picture frames and turnery. It is used also for construction, furniture, spinning wheels and ploughs. It is suitable for tool handles and cheaper types of guns and rifles (Pearson & Brown, I, 311–13 : Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1,** 75 : Limaye, ibid., 1954, **1,** 57, Sheet No. 16 ; Bor, 267 : Dastur, Useful Plants, 169 ; Howard, 485 : *Industry, Calcutta*, 1950–51, **41,** 299).

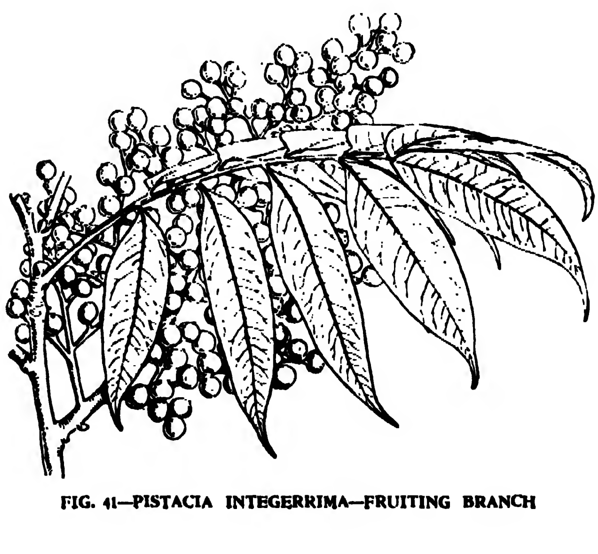
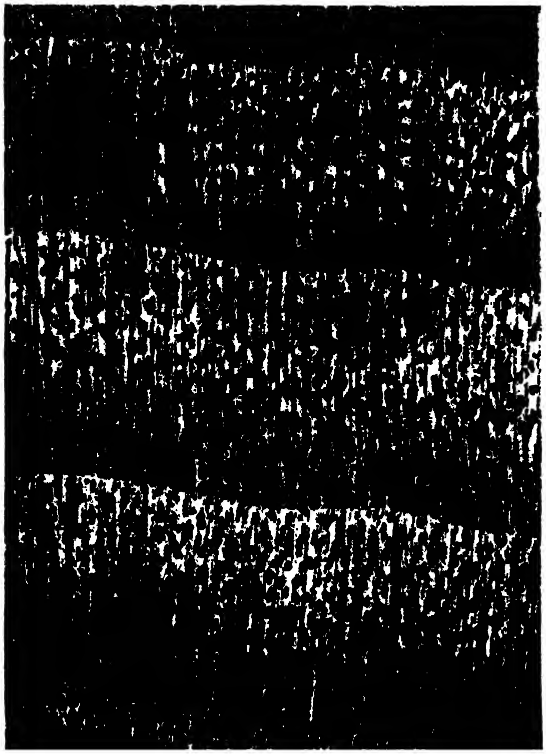


FIG. 41—PISTACIA INTEGERRIMA—FRUITING BRANCH



F.R.I., Dehra Dun. Photo : Ramesh Rao

FIG. 42—PISTACIA INTEGERRIMA—TRANSVERSE SECTION OF WOOD (×10)

Galls produced on the leaves and the petioles are used in medicine and for dyeing and tanning purposes. These galls (Indian Bazaars—*Kakra-singi, karkatasringi, kakarashingi*) are pale greenish brown in colour, horn-shaped, hard, rugose and hollow, varying in length from an average of 3.8 cm. to sometimes 30 cm. or more; inner surface is reddish in colour. Dry powdered galls have a very astringent and slightly bitter taste and a terebinthine odour. The galls are aromatic, astringent and expectorant and are valued in Indian medicine as a remedy for asthma, phthisis and other ailments of the respiratory tract; they are useful in dysentery (I.P.C., 206; Kirt. & Basu, I, 650).

The galls contain tannins (20–75%), an essential oil, and a resin (5%) which is identical with gum mastic from *P. lentiscus* (q.v.). The following compounds have been isolated from petroleum ether extract of the galls: two isomeric triterpenic acids designated pistacienoic acid A ($C_{30}H_{46}O_3$, m.p. 175–78°) and pistacienoic acid B (m.p. 158–61°), a triterpene alcohol ($C_{32}H_{52}O_2$, m.p. 132–33°) probably tirucallol, β-sitosterol and a waxy compound (m.p. 75–77°). The two triterpenic acids are ketocarboxylic and appear to be identical with the α- and β-acids ($C_{30}H_{44}O_3$, m.p. 179–80° and 161–62°, respectively) reported in the galls by an earlier worker [Chopra & Ghosh, *Indian J. med. Res.*, 1929–30, **17,** 377; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 153; Venkateswara Rao & Bose, *Trans. Bose Res. Inst.*, 1956–57, **21,** 23; Ghose, *Sci. & Cult.*, 1945–46, **11,** 46].

Steam distillation of the galls from Delhi market gave essential oil in a yield of 1.3 per cent. The oil was colourless when fresh, turning yellow on keeping and had the characteristic odour of the drug. The freshly distilled oil had the following physico-chemical constants: sp. gr.$^{13°}$, 0.8759; $n_D^{13°}$, 1.4735; $[\alpha]_D^{13°}$, −19.5°; sap. val., 22.1; acid val., 19.6; ester val., 2.5; ester val. after acetylation, 94.7; hydroxyl val., 28.4; and carbonyl val., 6.1. The oil contained: α-pinene, 25; camphene, 27; *dl*-limonene, 4–5; 1:8-cineol, 10; α-terpineol, 20; and aromadendrene, 4–5%. Small amounts of lactonic stearoptene and caprylic acid were also identified. A sample of the dried galls (from Agra) on steam distillation yielded 1.8 per cent of a light greenish yellow essential oil which differed from the above mentioned oil in being dextro-rotatory (α_D, +36°) and containing α-*d*-pinene (94%) as its chief constituent (Karimullah *et al.*, *J. sci. industr. Res.*, 1944–45, **3,** 423; Karimullah & Uma Shanker, ibid., 1946, **5B,** 60; Baslas & Deshpande, *J. Indian chem. Soc.*, 1950, **27,** 441).

The oil is used as a carminative. In moderate doses, it has an antispasmodic action on involuntary muscles inhibiting excessive peristaltic movements of intestine. It has a depressant action on the central nervous system of guinea-pigs and white rats when given in sub-lethal doses. The animals become deeply unconscious in about an hour. Lethal doses (m.l.d., 0.1 cc./100 g. body wt.) cause deep narcosis leading to death within a few hours. The oil has a slight irritant action on the skin and mucous membrane. It shows weak antibacterial and antiprotozoal activities (Chopra *et al.*, *Indian J. med. Res.*, 1954, **42,** 385).

The leaves and bark contain 16 per cent and 8 per cent tannins respectively. A sample of bark from Jammu & Kashmir contained 14 per cent tannin and 20.5 per cent non-tannin. The drupes on steam distillation yielded 0.9 per cent of an essential oil: from the residue were isolated two crystalline compounds provisionally named pistacin (m.p. 172°, yield 0.23%) and pistacinin (m.p. 110°, yield 0.35%). Leaves are lopped for fodder for buffaloes and camels (Edwards *et al.*, loc. cit.; Tej Singh *et al.*, *Indian For.*,

1958, **84**, 571; Bhargava, *Proc. Indian Sci. Congr.*, 1949, pt III, 77).

P. lentiscus Linn. MASTIC TREE

D.E.P., VI(1), 270; C.P., 902; Zohary, *Palest. J. Bot., Jerusalem Ser.*, 1950, **5**, 187.

A variable evergreen shrub or a small tree, up to 4 m. in height, with pinnate leaves and small (4–5 mm. diam.) globose black drupes found chiefly in the Mediterranean region. It yields mastic resin which is imported into India.

The main source of supply of mastic is the island of Chios in the Aegean Sea, where the mastic industry is now well organized. Mastic tree grows chiefly in the south-east corner of the island up to an altitude of 500 m.; average annual rainfall in the area is 73 cm. Propagation is done by cuttings; only male trees are cultivated as the female ones yield an inferior resin. The resin exudes naturally from the bark but for commercial purposes, it is obtained by making small vertical incisions in it and picking off the hardened product about three weeks later. Average annual yield of resin per tree is 3.6–5.4 kg. (Mantell, *Econ. Bot.*, 1950, **4**, 240; Howes, ibid., 1950, **4**, 307).

Mastic varies in colour and appearance according to the commercial grade, but generally occurs in globular, pyriform or elongated tears, 4–8 mm. in diam., pale yellow, clear and glassy when fresh, becoming dull and brittle on keeping; it has an aromatic odour and agreeable taste. Mastic has the following chemical composition: α-masticoresene, 30; β-masticoresene, 20; α-masticonic acid, 20; β-masticonic acid, 18; α- and β-masticinic acids, 4; masticolic acid, 0.5; and an essential oil, 2%; a bitter substance is also present. The colourless essential oil, obtained by the steam distillation of mastic (yield 1–3%), shows a strong balsamic odour and contains α-*d*-pinene as the principal constituent (B.P.C., 1963, 456; Hoppe, 708; Gildemeister & Hoffmann, V, 707).

Mastic has been used especially in the Mediterranean countries, as a masticatory to sweeten the breath and to preserve teeth and gums; at present it is used in the preparation of chewing gum. It has been used also to flavour alcoholic beverages and cordials. Mastic (*Rumi-mastaki*) has been considered carminative, stimulant and diuretic; its use in medicine is now restricted, though it still enters into the preparation of various pharmaceutical products, perfumes and incenses. It is used also as a temporary filling of carious teeth and in paints used as protective covering for wounds. It is suitable also as a microscopical mountant. The principal use of mastic is in the manufacture of high grade transparent varnishes employed for coating valuable art paintings and metals, for lithographic processes and retouching negatives (Howes, *Econ. Bot.*, 1950, **4**, 307; Uphof, 284; B.P.C., 1963, 456; Trease, 351).

The seeds yield over 30 per cent of a fatty oil, with a slightly sweet taste and an aromatic odour, and used locally for edible purposes and soap making. The leaves (tannins, 9–19%) are used for tanning and as adulterant of sumac. They also contain myrecetin, probably as a glucoside, and quinic and shikimic acids. Essential oils occur both in the fruits and leaves (Marcopoulos, *J. Amer. Oil Chem. Soc.*, 1965, **42**, 1; Eckey, 619; Howes, 1953, 283; Perkin & Everest, 448; *Chem. Abstr.*, 1935, **29**, 368; 1938, **32**, 9532; 1960, **54**, 15546; Gildemeister & Hoffmann, V, 707–08).

P. vera Linn. PISTACHIO

D.E.P., VI(1), 273; C.P., 902; Zohary, *Palest. J. Bot., Jerusalem Ser.*, 1950, **5**, 187.

A small deciduous tree, up to 10 m. in height; branches spreading; leaves imparipinnate; leaflets 5–10 cm. × 3–6 cm., lanceolate to broadly ovate, leathery; flowers in panicles, minute; drupe oblong-linear to globose, laterally compressed, 10–20 mm. × 6–12 mm.; outer husk variously coloured, readily separating from the dehiscent or indehiscent, greyish white, bony, keeled nut-shell (endocarp) which encloses light yellow to deep green edible kernel with a reddish coat.

P. vera is a native of the eastern Mediterranean region, Iran, Afghanistan and Central Asian countries; it possibly had its origin in Central Asia. It is grown on a commercial scale chiefly in Italy, Turkey, Syria, Iran and Afghanistan and to a lesser extent in Lebanon and West Pakistan, mostly for the export of pistachio nut; it is also cultivated on a small scale in California. Trade varieties of pistachio are named after their countries of origin, i.e. Iranian, Afghan, Turkish, Syrian, etc. (Whitehouse, *Econ. Bot.*, 1957, **11**, 281; Bagenal, *World Crops*, 1962, **14**, 188).

Pistachio (INDIAN TRADE—*Pista*) is imported in considerable quantities into India (Table 1), chiefly from Afghanistan and Iran; small quantities are also re-exported. *Pista* kernels have a delicious nutty flavour and are much used as ingredients of sweet-

TABLE 1—IMPORT OF PISTACHIO NUTS INTO INDIA

Year	Qty (kg.)	Val. (Rs.)
1960–61	1,227,542	8,638,194
1961–62	291,402	1,932,840
1962–63	461,785	3,165,315
1963–64	817,642	5,653,462
1964–65	555,729	4,119,793
1965–66	131,598	1,430,750

meats, confectionery and ice-creams. *Pista* is also eaten as a dessert; salted and roasted, it is much relished. It is considered to be digestive, sedative and tonic. Fruit husks are reported to be made into marmalade in Iran; they are also used as fertilizer. Analysis of pistachio kernels gave the following values: moisture, 5.6; protein, 19.8; fat, 53.5; carbohydrates, 16.2; fibre, 2.1; mineral matter, 2.8; calcium, 0.14; and phosphorus, 0.43%; iron, 13.7 mg.; carotene (as vitamin A), 240 I.U.; thiamine, 0.67; riboflavin, 0.03; nicotinic acid, 1.4 mg.; vitamin C, nil; and calorific val., 626 cal./100 g. Nuts and seeds contain pectin (as calcium pectate, dry basis), 3.53 per

FIG. 43—PISTACIA VERA—SHELLED AND UNSHELLED NUTS

cent (Whitehouse, loc. cit.; Nutritive Value of Indian Foods, 65, 100, 130; Trehan & Bashir Ahmad, *J. sci. industr. Res.*, 1947, **6B**, 16).

Pistachio kernels yield *c.* 50 per cent of a low melting fatty oil used to a small extent in confectionery as spice oil and in medicine. Ordinarily the oil is not produced as such because of the value of the nuts themselves. The cold pressed oil is golden yellow without much odour, but the solvent extracted oil is dark green and has an aromatic odour. The oil is said to turn rancid easily. The physico-chemical properties of the oil are as follows: sp. gr.$^{15}_{15}$, 0.918–0.920; $n_D^{25°}$, 1.467–1.470; acid val., 0.5–4.0; sap. val., 191–95; iod. val., 84–94; R.M. val., 0.5; titre, 13–16°; m.p., *c.* 5°; and unsapon. matter, 0.4–1.0%; fatty acid composition: myristic, 0.6; palmitic, 8.2; stearic, 1.6; oleic, 69.6; and linoleic, 19.8% (Hoppe, 709; Eckey, 616, 619; Dhingra & Hilditch, *J. Soc. chem. Ind., Lond.*, 1931, **50**, 9T).

The leaves of *P. vera* bear small, irregularly spheroid galls (Bokhara galls) which have been reported to be imported into India for dyeing and tanning purposes; galls contain 50 per cent tannins. Shikimic acid is present in the young and mature leaves of pistachio. The tree also yields a resin [Howes, 1953, 266; Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 153; *Chem. Abstr.*, 1960, **54**, 15546; Whitehouse, loc. cit.].

P. khinjuk Stocks is a shrub or small tree found from western Asia to Chitral and Gilgit in Kashmir. It yields hard galls, occasionally used for tanning and dyeing. The leaves are used as fodder for camels and buffaloes and the wood is suitable for furniture and ornamental work. *P. khinjuk* is one of the sources of Bombay mastic, which is very similar to true mastic, but darker in colour. Bombay mastic is imported into India and used as a substitute for mastic; on distillation, it gives a pale yellow essential oil. *P. atlantica* Desf. var. *kurdica* Zohary syn. *P. terebinthus* Linn. var. *mutica* Aitch. & Hemsl. and possibly some other species of *Pistacia* found in the Central and the South-West Asian countries also yield Bombay mastic (Uphof, 284; Mantell, *Econ. Bot.*, 1950, **4**, 240; Dutt, *Indian Oil & Soap J.*, 1961–62, **27**, 95).

PISTIA Linn. (*Araceae*)

A monotypic genus of floating aquatic herbs, represented by *P. stratiotes*, distributed in the tropical and sub-tropical Asia, Africa and America. Four varieties are distinguished. The Indian variety is known as var. *cuneata* Engl.

P. stratiotes Linn. var. **cuneata** Engl. WATER LETTUCE, TROPICAL DUCKWEED

D.E.P., VI(1), 275; Fl. Br. Ind., VI, 497; Kirt. & Basu, Pl. 993.

HINDI—*Jalkhumbi, takapana*; BENG.—*Takapana*; MAR.—*Prasni, gondala, jalamandvi*; GUJ.—*Jalashamkhala*; TEL.—*Antharai-dhaman, nirubuduki, anthara thamara*; TAM.—*Akasa tamarai, koditamarai*; MAL.—*Akasa thamara, kudapayal, muttapayal*; KAN.—*Antara gange*; ORIYA—*Borajhanji*.

A floating aquatic, stoloniferous herb found in ponds and streams almost throughout India up to a height of 1,000 m. Leaves sessile, ovate to obovate-cuneate, densely pubescent; spathe 2–4 cm. long, tubular at its base, free and spreading above, slightly constricted above the middle; flowers minute, sessile on a spadix; fruits ovoid to ellipsoid, green, crowned by persistent style; seeds few to many, oblong or ovoid with a broad top.

P. stratiotes propagates by seeds or more rapidly by stolons. It forms a dense mat on water surface and causes serious clogging of waterways; it is also responsible for harbouring mosquito larvae which carry the filarial parasite. It flowers in the hot season and fruits appear after the rains. It can be eradicated by applying MCPA (0.2%) at the rate of 2.2 kg. per hectare. The plant is popular for growing in aquarium [Wilson, *J. Arnold Arbor.*, 1960, **41**, 61; Gopinath, *J. Bombay nat. Hist. Soc.*, 1942–43, **43**, 664; Ram Gopal, *Indian Fmg, N.S.*, 1954–55, **4**(10), 23; Chittenden, III, 1590].

The plant is eaten in parts of tropical Africa and in India, in times of famine. Young leaves are cooked and eaten by the Chinese; they are at first insipid, but later biting. The plant is said to afford an excellent food for fishes; in North Nigeria, it is given for ostriches; in Malaya, the leaves and stems are used as a succulent pig food. An analysis of leaves and stems gave: moisture, 92.9; protein, 1.4; fat, 0.3; carbohydrates, 2.6; fibre, 0.9; ash, 1.9; calcium (CaO), 0.20; phosphorus (P_2O_5), 0.06; and dig. protein, 1.2%; nutritive ratio, 3.1. They are rich in vitamins A and C and also contain B vitamins (Fl. Egypt, II, 360; Burkill, II, 1756–57; Bruggeman, 122; Dalziel, 483; Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 16, 68, 77, 83).

The incinerated plant yields a saltish ash (*pana* salt) rich in potassium chloride and sulphate. The ash is said to be used for soap making in west tropical Africa. Because of its high potash content, the plant is also valued as manure. Compost made from the plant had: pH, 7.5; organic carbon, 1.31%; available nitrogen, 38.08 mg.; and available phosphorus, 10.05 mg./100 g. (Burkill, II, 1757; *Bull. imp. Inst., Lond.*, 1917, **15**, 283; Dalziel, 483; Singh, *Proceedings of 10th Session Indo-Pacific Fisheries Council, Seoul*, 1962, 141).

A number of medicinal properties are attributed to the plant, particularly the leaves. The plant is considered antiseptic, antitubercular and antidysenteric. In Gambia, the plant is used as an anodyne for eyewash. Juice of the plant is used by the Mundas in ear complaints. The ashes of the plant are applied to the ringworm of the scalp. The leaves are used in eczema, leprosy, ulcers, piles and syphilis. With rose water and sugar they are given for cough and asthma. Leaves are said to be anthelmintic. Juice of the leaves boiled in coconut oil and applied externally in chronic skin diseases gave relief in a number of cases (Chopra, 1958, 598, 601, 605; Kirt. & Basu, IV, 2601; Rama Rao, 425; Koman, 1920, 7).

PISUM Linn. (*Leguminosae*; *Papilionaceae*)

A small genus of soft annual and perennial herbs distributed in the Mediterranean region, West Asia and North-East Africa. One species, *P. sativum*, is widely grown for its edible seeds and as fodder.

P. sativum Linn. syn. *P. arvense* Linn. PEA

D.E.P., VI(1), 276; Bailey, 1947, III, 2490, 2650; Mansfeld, 196.

HINDI & BENG.—*Matar*; MAR. & GUJ.—*Watani*; TEL.—*Patanlu*; TAM. & MAL.—*Pattani*; KAN.—*Batani, batagadle*.

An annual herb with hollow stems ending in one or more tendrils; leaves pinnately compound, with auricled stipules; flowers white, bluish or purple coloured; pods straight or curved, pointed or blunt, 5–10 cm. long with a thick or thin wall; seeds 6–9, green, yellow-green, blue-green, white-grey, brown or mottled, smooth and rounded or flattened and wrinkled, varying in size from 3.5 to 5.0 mm.

Considerable confusion exists regarding the specific delimitation of *P. sativum*. Some authors keep the field pea as a separate species *P. arvense* Linn., considering it as an intermediate stage of progression from wild field pea to cultivated garden pea. Others include both the field pea and the garden pea under *P. sativum*, as sub-species or varieties, since they are reported to cross sometimes under natural conditions. The differences between the two groups are confined

I.A.R.I., New Delhi

FIG. 44—PISUM SATIVUM CONVAR. SATIVUM—FRUITING BRANCH

to minor characters like the habit of the plant, the colour and size of flowers and seeds. In general, the garden pea is scandent and more robust than the field pea and bears white flowers and white, greenish or yellowish seeds, which may be round or wrinkled and angular. There are two major groups of garden pea, those grown for seeds (Shelling Peas) and those grown for edible pods (Sugar Peas). The latter have large, soft pods, lacking the stiff transparent inner membrane, so that the entire tender pod can be eaten like French beans. The field pea generally bears bluish or purple flowers and angular and marbled seeds, which may be grey, brown or mottled. These differences are not absolute; there are types of garden pea with dwarf habit and coloured flowers and types of field pea, with vigorous habit and white flowers. Based on the above mentioned characters, *P. sativum* sensu lato, is classified as follows: subsp. *sativum* convar. *sativum*, the GARDEN PEA (*Gol matar* or *Kabuli matar*); subsp. *sativum* convar. *speciosum* (Dierb.) Alef. (syn. *P. arvense* Linn. and *P. sativum* var. *arvense* Poir.), the FIELD PEA (*Desi matar*); and subsp. *sativum* convar. *axiphium* Alef., the SUGAR PEA (Zukovskij, 23; Lehmann, *Zuchter*, 1954, **24**, 316; Howard *et al.*, *Mem. Dep. Agric. India, Bot.*, 1910, **3**, 303).

Cultivated pea is of great antiquity and the evidence of its cultivation in Europe has been traced to the Bronze Age. No wild types of garden pea are known, but undoubted wild types of the field pea are recorded in the sub-alpine regions of Georgia in U.S.S.R. Some of these wild types belong to the species *P. elatius* Steven., a weed found growing among grain crops and distributed from Europe eastwards to Central Asia and southwards to Ethiopia. Other closely related species found wild are *P. fulvum* Sibth. et Sm., and *P. syriacum* (Berger) Lehm. syn. *P. humile* Boiss. et Noe, non Miller. It is believed that the cultivated peas, garden pea as well as field pea, have originated by hybridization among some of these species and by their back-crossing and mutation, in the various regions. Four centres of origin are recognized, of which two are considered primary; one is the Mediterranean region, characterized by types with predominantly large pods and seeds and the other North-West India and Afghanistan, characterized by smaller fruits and seeds, but possessing valuable properties, like speedy maturation and resistance to drought (Vavilov, 31–33, 35, 37; Vavilov, 1957, 57; Crane & Lawrence, 98; Mansfeld, 196; Zukovskij, 23).

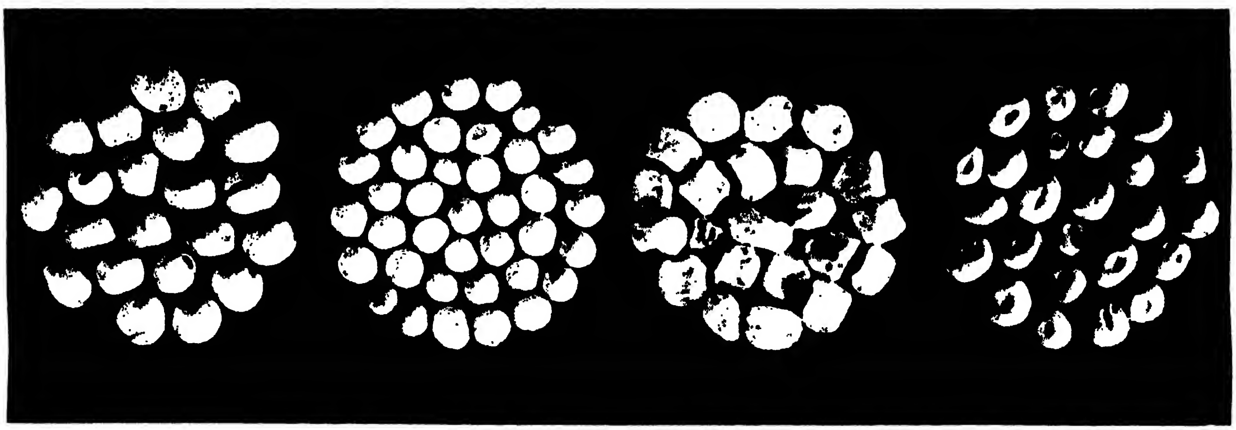
There are very few vegetables which have developed greater varietal differences, affecting their horticultural and culinary values as the peas. Peas are one of the earliest crops, with which controlled breeding work has been undertaken for the production of improved types and it is the work on this crop by Mendel, that has led to the foundation of the modern science of genetics. All the forms of cultivated pea so far studied have $2n = 14$ chromosomes, although a few tetraploid forms are also known. Extensive hybridization has been carried out mostly between varieties, and inheritance of pod, seed and plant characters has been investigated. It has been shown that the number of independent factors and groups of factors exceeds the number of chromosomes and the linkage value for given genes varies considerably. Eight linkage groups have been recognized. It has been found that in addition to their morphological variations, great variations also exist in the protein content of the seeds in different types, and these types though morphologically homozyg-

ous have been found to be heterozygous for their protein content. Resistance to fusarium root-rot is due to a single dominant gene and types originating in India and some other countries like Ethiopia and Turkey are said to be resistant to this disease. The inheritance of resistance to several other diseases like mildew, damping off and mosaic, and to pests like aphids has also been investigated (Wade, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 251 ; Crane & Lawrence, 99 ; Yarnell, *Bot. Rev.*, 1962, **28,** 465).

A large number of types of pea have been evolved by breeders in England, Europe and America. The early peas were smooth seeded, mostly tall, small podded and late maturing types ; strains with wrinkled seed and larger pods were obtained later, the quality of sweetness being brought in along with the wrinkled character of the seed. Breeding work has been mainly in the direction of evolving types characterized by sturdy vines, larger pods, higher yields, better quality, early maturity, and resistance to diseases. With the advent and popularization of canning, separate types have been evolved to suit the industry, as distinct from the market garden types. Attempts are being made to develop types especially adopted to preservation by freezing. A number of types have been evolved which are resistant to some of the diseases like foot-rot and wilt caused by *Fusarium* sp., mildew caused by *Erysiphe*, damping off caused by *Pythium* sp., and to virus diseases ; types resistant to insect pests and cold have also been developed (Crane & Lawrence, 97 ; Wade, loc. cit. ; Richharia, 204).

A very large number of types of the garden pea are under cultivation and these have been variously classified. They can be divided into five main groups according to use or they may be separated into two main classes, based on the character of the seed coat, which may be either smooth or wrinkled ; and these groups are further classified as dwarf, semi-dwarf, or climbing and again on the basis of the colour of the seeds, as green or white, and according to season, as early, midseason or late. The choice of types for cultivation in any locality depends on these characters as well as others, such as the length of time taken by the crop to ripen, yielding capacity, shell-out percentage or relative weight of peas and pods, resistance to diseases and lastly the taste, flavour and colour of seeds (Bailey, 1947, III, 2490 : Bell, 108 ; Wade, loc. cit. ; Joshi, S. N., *Thesis*, No. 512, *Indian agric. Res. Inst., New Delhi*, 1954 ; Sneddon & Squibbs, *J. nat. Inst. agric. Bot.*, 1958, **8,** 378 ; Singh, *Indian J. Hort.*, 1954, **11,** 113).

The cultivated peas of Uttar Pradesh, the most important pea growing State in India, are placed in three broad groups, viz. *desi* peas, white peas, and table or garden peas. The major part of the crop is said to be generally a mixture of white and *desi* peas, the garden peas being of importance only near the larger cities and to some extent in Kumaun hills. Though the *desi* peas are not superior in yield to the white peas, they are preferred by the farmers as they are not much damaged by birds. A number of types of the garden peas are being grown in different States and many new types have been introduced from



LARGE SMOOTH SMALL SMOOTH WRINKLED DIMPLED

FIG. 45—PISUM SATIVUM—SAMPLES OF DRIED SEEDS

abroad. A few selections have also been made of garden peas as well as field peas, for their desirable characters. Table 1 summarizes the types grown in different States and Table 2 the characteristics of some important types grown or recommended in different States [Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1955, **6**(2 & 3), 6, 32].

TABLE 1—IMPORTANT TYPES OF PEA CULTIVATED IN DIFFERENT STATES

State	Types	Centres of production*
Assam	Darjeeling, Desi	Shillong
Bihar	BR-2, 12, 118 & 178, Desi, N.P. 29, Telephone	Patna, Ranchi
Madhya Pradesh	Desi, Indore Wrinkled, Khaparkheda, N.P. 29	Nagpur
Madras	Desi, Duke of Albany, Early Giant, Marrowfat, Peerless, Radio	Nilgiri hills
Maharashtra	Desi, Poona Local, Wai, No. 23 & No. 43	Poona, Nasik
Mysore	Bangalore Local, Mange-tout†, Telephone	Belgaum, Bangalore
Punjab & Himachal Pradesh	Desi Bauna (Lucknow Boniya), Do Futta (Kirpan, Lincoln, or Greenfeast), Early Giant, Farshi, Hara Bauna (China), Little Marvel, P.I.D., P-8 (Premium Gem), P-35 (Perpetual), Simla (Kannauri), Kali Nagiri	Ambala, Hoshiarpur, Attari, Amritsar, Hill Districts, Simla, High & medium elevations, Chini
Uttar Pradesh	American Wonder, Blue Bantam, Desi Types (Burhea, Dabla, Rajmahali), Early Badger, Early December, First to Report, Hundredfold, Kalianpur White, Long Marrowfat, Lincoln (Darantia Kaip), Lucknow Boniya, Thomas Laxton, Telephone, N.P. 29 (Karnal Pea), Types 17, 18, 19, 56, 61 & 163	Allahabad, Lucknow, Meerut, Naini Tal
West Bengal	Alderman, Desi, Marrowfat	Darjeeling
Delhi	Asauji, Bonneville, Desi Bauna, Delwiche Commando, Early Badger, Early Perfection, Early to Report, Little Marvel, Lincoln (Darantia Kaip), N.P. 29, Sylvia†	Delhi

* Relating mainly to green peas.
† Sugar pea recommended for edible pods.

CULTIVATION

Pea is grown as a garden or field crop throughout the temperate regions of the world or as a cool season crop or hilly country crop in the tropics. Some of the important countries where pea is grown in large areas are: China, U.S.S.R., India, U.S.A., Ethiopia and Congo, the first three accounting for more than three-fourths of world production (Table 3).

In India, the crop is grown on a field scale for its dry seeds and on a smaller scale for green peas near the larger cities and towns. The most important State cultivating pea on a field scale is Uttar Pradesh, which includes about 83 per cent of the total area under this crop in the country, followed far behind by Bihar (6.8%), Madhya Pradesh (6.7%) and others (Table 4). The chief producing districts of Uttar Pradesh are: Aligarh, Basti, Azamgarh, Bulandshahr, Meerut, Gorakhpur, Faizabad, Etah, Mainpuri, Etawah, Allahabad, Deoria and Gonda, which together include about half the total area under this crop in the country. The districts of Monghyr, Shahabad, Gaya and Saran in Bihar, Mandla and Narasinghpur in Madhya Pradesh, Poona, Satara and Kolhapur in Maharashtra, and Gurgaon in Haryana have also large areas under this crop.

Statistics of area and production of green pea grown as vegetable on all-India basis are not maintained, but data collected by the Directorate of Marketing and Inspection, for 1961–62 show that Uttar Pradesh again leads in the cultivation of green peas with 44.3 per cent of total area and 45.9 per cent of production, followed by Bihar with 15.9 per cent of the area and 13.1 per cent of production, while Punjab, Haryana, West Bengal, Maharashtra, Rajasthan, Delhi and Gujarat follow far behind (Table 5). The chief cultivating districts in the several States are: Saharanpur, Varanasi, Allahabad, Gorakhpur, Bulandshahr, Bareilly, Meerut, Lucknow, Kanpur, Mathura, Naini Tal, Almora and Dehra Dun in Uttar Pradesh; Ranchi, Hazaribagh, Gaya and Patna in Bihar; Amritsar, Hoshiarpur, Patiala and Jullundur in Punjab; Gurgaon and Ambala in Haryana; 24-Parganas, Hooghly, Darjeeling, Murshidabad, Burdwan and Nadia in West Bengal; Nasik, Poona, Satara and Sholapur in Maharashtra; Kotah and Sawai Madhopur in Rajasthan; Baroda, Kaira and Surat in Gujarat; Bangalore, Kolar, Belgaum in Mysore; Mahasu in Himachal Pradesh; Khasi-Jaintia hills and Kamrup in Assam; and the Union Territory of Delhi (Information from the Directorate of Marketing and Inspection, Nagpur).

TABLE 2—CHARACTERISTICS OF IMPORTANT TYPES OF PEAS GROWN OR RECOMMENDED FOR CULTIVATION IN INDIA*

Type	Habit and growing period	Characteristics of pods and seeds	Remarks
Asauji	Dwarf, up to 40 cm. in height; early, sown from mid-September; pods ready in 60 65 days	Bears 5 7 pods per plant; seeds round & plump, bluish green; shell out percentage 40	Selection from local Hara Bauna or China
Early Badger	Dwarf; sown in early October; pods ready in 60 65 days	Pods well filled, borne mostly singly; seeds wrinkled, sweet; yields up to 8,600 kg. ha. of pods or 1,800 2,850 kg. ha. of dry peas; shell-out percentage 40	Introduced from America; suitable for canning; grown in Uttar Pradesh & Delhi
Early Giant	Tall; sown in early October; pods ready in 60-65 days	Pods big, deep green; seeds wrinkled, sweet; yield of pods c. 7,250 kg. ha.	Recommended for hills; suitable for canning; grown in Madras & Punjab
Bonneville	Medium tall; suitable for main season crop; sown in October; comes to harvest in 85-100 days	Prolific bearing; seeds wrinkled, very sweet; yield of dry peas 2,460-3,850 kg. ha.; shell-out percentage 48	Introduced from America; less susceptible to wilt; suitable for canning; grown in Delhi
Sylvia	Tall, slender stemmed; suitable for main season; sown in October; pods harvested after c. 95 days; does best when staked	Pods soft, curved, without the inner parchment-like layer and can be consumed as such; a 40 m. row of staked plants yields c. 30 kg. of pods	Introduced from Sweden; grown in Delhi for pods
Little Marvel	Dwarf; early type	Pods medium-sized, thick, well-filled; seeds sweet, wrinkled	Suitable for canning; grown in Punjab & Delhi
Kinnauri (Simla)	Rather tall; sown in October; comes to harvest in April and continues to May	Pods of good size, usually borne singly; seeds smooth and white	Grown in Simla hills, Ambala, Chini region of Himachal Pradesh, & Naini Tal (Uttar Pradesh)
Lincoln (Green-feast, Darantia Kaip, Kirpan, Do Futta)	Dwarf to medium-tall; suitable for early sowing; comes to harvest in 100 days	Pods dark green, sickle shaped; seeds rather small, wrinkled	Introduced from U.K.; grown in Uttar Pradesh, Delhi & Punjab
Lucknow Bouiya (Desi Bauna)	Dwarf; early type	Pods short, usually borne singly; seeds white, smooth	Commonly grown around Meerut, Lucknow (Uttar Pradesh) & Ambala
Delwiche Commando	Medium-tall; suitable for main crop; sown mid-October to mid-November; comes to harvest in 80 85 days	Pods generally borne double; seeds wrinkled; yields up to 15,000 kg./ha. of pods or 1,800 2,200 kg. ha. of dry peas; shell-out percentage 45	Introduced from America; grown in Delhi
N.P. 29	Tall, mid season type; can be sown as late as mid-December; comes to harvest in 100 days	Pods long; seeds wrinkled and sweet; yield of dry peas 2,700 2,900 kg. ha.; shell-out percentage 50	Released by the Indian Agricultural Research Institute, New Delhi; grown in Uttar Pradesh, Bihar, Madhya Pradesh & Rajasthan
Type 56	Dwarf; can be sown as late as mid-December; comes to harvest in 75 days	Pods green; seeds highly wrinkled, greenish white, sweet; yield of pods c. 7,250 10,000 kg. ha.	Developed in Uttar Pradesh as a cross between N.P. 29 and Type 18
Type 61	Moderate growth; pods ready for picking in 80-85 days	Seeds light green & sweet to taste; yield of pods c. 9,200 12,000 kg. ha.	A cross of Type 20 with N.P. 29 developed in Uttar Pradesh
Type 163	Suitable for both early and late sowings	Seeds white, bold & smooth; yield of dry peas c. 2,460-4,100 kg./ha.	Selection from Uttar Pradesh; cultivated for table as well as for dry peas
Type 19	Medium in maturity; comes to harvest in 75 days of sowing	Seeds highly wrinkled, greenish white, exceptionally fine in taste; yield of pods c. 8,250 10,000 kg./ha. & yield of dry peas c. 1,750 2,200 kg./ha.	Selection from Thomas Laxton; recommended for cultivation as table pea in Uttar Pradesh

Contd

TABLE 2—*Contd*

Type	Habit and growing period	Characteristics of pods and seeds	Remarks
Early December	Dwarf, early type; sown in mid-October; comes to harvest in 55 days from sowing	Seeds wrinkled	Developed in Uttar Pradesh as a cross between Type 19 and Early Badger; recommended for western Uttar Pradesh, plains of Punjab, Delhi, Rajasthan & northern Madhya Pradesh
P.I.D.	Dwarf, early type; sown by first week of September; first picking in *c.* 45 days after sowing	Seeds smooth; yield of pods *c.* 2,800 3,600 kg./ha.; shell-out percentage 50	A selection from a local type of peas from Hoshiarpur (Punjab); suitable for plains
P-8 (Premium Gem)	Medium-tall, early type; comes to harvest in *c.* 56 days after sowing	Seeds wrinkled, green; yield of pods 7,250 9,250 kg./ha.; shell-out percentage 56	Introduced from U.S.A.; grown in Punjab; suitable for the hills
P-35 (Perpetual)	Dwarf, mid-season type; takes about 98 days after sowing to come to harvest	Seeds wrinkled, green; yield of pods 8,250 10,000 kg./ha.; shell-out percentage 52	Introduced from U.S.A.; grown in Punjab; suitable both for plains and hills

* Singh & Sikka, *Indian Fmg, N.S.*, 1954 55, **4**(9), 25; Katyal & Sabharwal, *Indian Hort.*, 1961 62, **6**(1), 15; Pathak & Sahai, ibid., 1958 59, **3**(4), 25; Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1955, **6**(2 & 3), 59; Milne *et al.*, 90; Purewal, *Farm Bull.*, No. 36, 1957, 37; *Agric. Marketing India, Brochure Marketing Green Peas in India, Marketing Ser.*, No. 127, 1960, 6 7; Wakankar & Mahadik, *Indian Fmg, N.S.*, 1961-62, **11**(5), 8; *Agric. Res.*, 1962, **2**, 6, 77; *Annu. sci. Rep. Indian agric. Res. Inst.*, 1956 57, 34.

TABLE 3—AREA AND PRODUCTION OF DRY PEAS IN MAJOR PRODUCING COUNTRIES*

Country	Area (thousand hectares)					Production (thousand tonnes)				
	1961	1962	1963	1964	1965	1961	1962	1963	1964	1965
China	3,250	3,300	3,400	3,400	3,400	2,800	2,900	3,000	3,100	3,100
U.S.S.R.	1,969	4,323	7,768	7,750†	4,950†	2,182	5,274	6,450†	8,380†	4,575†
India	1,177	1,258	1,325	1,300	1,122	1,050	1,103	1,026	670	926
U.S.A.	136	139	127	120	90	161	230	222	221	185
Ethiopia	122	124	126	127	127	110	112	113	115	117
Congo	120†	125†	128†	130†	130†	66†	68†	75†	80†	80†
Others	871	919	947	920	930	924	985	1,017	1,009	1,102
World Total	7,645	10,188	13,821	13,747	10,749	7,293	10,672	11,903	13,575	10,085

* *Prod. Yearb. FAO*, 1966, **20**, 144. † FAO estimate.

TABLE 4—AREA AND PRODUCTION OF FIELD PEA (DRY) IN INDIA

State	Area (thousand hectares)				Production (thousand tonnes)			
	1963 64	1964 65	1965 66	1966 67	1963 64	1964 65	1965 66	1966 67
Uttar Pradesh	1,095.9	920.7	906.5	916.5	593.0	840.6	724.5	601.4
Bihar	79.4	74.4	79.1	n.a.	37.6	44.1	45.0	n.a.
Madhya Pradesh	70.9	69.4	68.8	62.9	18.3	19.4	16.7	12.7
Punjab	10.5	16.9	12.5	13.7	3.8	3.7	3.7	4.7
West Bengal	16.1	12.7	9.4	9.3	8.1	4.9	5.5	4.1
Maharashtra	9.5	9.9	8.9	10.2	3.2	3.6	2.2	2.8
Rajasthan	4.4	4.1	5.3	5.0	1.8	2.4	2.4	2.5
Assam	3.9	4.0	4.5	4.4	0.9	1.0	1.1	1.1
Himachal Pradesh	0.4	0.5	0.1	0.4	0.1	0.1	0.1	0.1
TOTAL	1,291.0	1,112.6	1,095.1	1,022.4	666.8	919.8	801.2	629.4

n.a.—not available.

TABLE 5—ESTIMATED AREA AND PRODUCTION OF GREEN PEAS IN INDIA*

(1961 62)

State	Area (hectares)	Percentage of total area	Production (tonnes)	Percentage of total production	Av. yield per hectare (tonnes)
Uttar Pradesh	16,900	44.3	78,370	45.9	4.6
Bihar	6,070	15.9	22,390	13.1	3.6
Punjab	3,510	9.2	19,420	11.4	5.5
West Bengal	3,010	7.9	13,370	7.8	4.4
Maharashtra	2,200	5.8	8,150	4.8	3.7
Rajasthan	1,570	4.1	8,700	5.1	5.5
Delhi	1,480	3.9	6,810	4.0	4.6
Gujarat	1,200	3.2	4,450	2.6	3.7
Mysore	640	1.7	2,560	1.5	4.0
Himachal Pradesh	610	1.6	3,360	2.0	5.5
Assam	320	0.8	740	0.4	2.3
Jammu & Kashmir	180	0.5	1,010	0.6	5.6
Andhra Pradesh	180	0.5	690	0.4	3.8
Madras	160	0.4	600	0.4	3.7
Others	90	0.2	90	(a)	1.0
TOTAL	38,120	100.0	170,710	100.0	4.4

* Data obtained from the Directorate of Marketing and Inspection, Ministry of Food & Agriculture, Govt. of India, Nagpur.
(a) Negligible.

Climate—Pea is adapted to a temperature range of 7–24°, with an optimum range of about 21°. The field pea is grown almost exclusively as a rabi or cold weather crop in the plains of northern India and as a kharif crop on the hills, between June and October. Garden pea is also grown mainly during winter in the plains and during spring and summer in the hills. Garden pea yields best when the crop matures under fairly cool climatic conditions. Hot dry weather interferes with seed setting, lowering the quality of pods. Peas grow best in regions where there is a slow transition from cold to warm weather. Seeds can germinate at a minimum of 5°. In the southern parts of the country, it is sown in plains from October to December; on the hills it is sown from March to end of May and as a second crop in autumn. The main crops of field pea are sown in September–November in the plains. There are early, medium and late maturing types and the best method of obtaining a succession of peas is to sow all of them early, at about the same time. Early sowing is said to be of greater importance for the late maturing types than for quick maturing ones and generally late sowings yield less [Roberts & Kartar Singh, 363; Agricultural and Horticultural Seeds, 277; Purewal, *Farm Bull.*, No. 36, 1957, 34–41; Choudhury, 113; Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1955, **6**(2 & 3), 9; Thapar, 196; Gopalaswamiengar, 544; Thompson & Kelly, 463].

Soil—The field pea is generally grown on loams and clay loams. The garden pea can be grown on a variety of soils, from light sandy loam to heavy clays. For a very early crop sandy loam is desirable, but where large yield and not earliness is important, a well drained clay loam or silt loam is preferred. Where facilities for irrigation exist, the texture of the soil is of little importance so long as the soil is well drained. The crop does not thrive on a highly acid soil, the desirable range being *p*H 5.5 to 7.5. In soils below *p*H 6.6, addition of an adequate amount of lime is necessary (Purewal, loc. cit.; Choudhury, 113).

Manuring—A thorough preparation of the soil is usually required for peas, as otherwise germination of the seeds may be uneven and wide variations may occur in maturity at harvest time. The coarser types, such as field peas, do not receive such a careful preparation of the land as the garden peas. Well-rotted farmyard manure at 20 cartloads per hectare may be applied to the crop, but it is often applied to the preceding crop. Trials at Pusa (Bihar) have shown that where the crop is irrigated, an application of 22.5 kg. of nitrogen and 67.5 kg. of phosphorus per hectare is beneficial. Investigations conducted in Delhi show that rock phosphates are not as effective as superphosphate or bone meal, in stimulating nitrogen fixation, though their use can be recommended where available. In the case of the rainfed crop, the response to fertilizers is varied. In trials conducted at Pusa (Bihar), application of nitrogen gave no significant response and at 22.5 kg. per hectare had even a tendency to depress the yields. With regard to application of phosphates, the response varies with rainfall and also with the different types cultivated, various doses applied and mode of application. Application of phosphates not only increases yield and quality, but also favours nodule formation. Potassic fertilizers are said to have good effect on yield and nitrogen fixation. The entire dose of fertilizers should be applied at the time of sowing. Application of fertilizers by broadcasting

or in direct contact with seed is said to result in lower yields, than those obtained when the fertilizers are placed in bands about 1.5 cm. to the side and 2.5 cm. deeper than the seed. Under soil conditions where molybdenum naturally present in the soil is inaccessible to the crop, application of granulated superphosphates enriched with microdoses of molybdenum is said to be beneficial [Mehta, loc. cit.; *Indian Fmg, N.S.*, 1961–62, **11**(8), 33; Vyas, *J. Indian Soc. Soil Sci.*, 1953–54, **1**, 41; Vyas & Desai, ibid., 1953–54, **1**, 32; Sharma & Misra, *Indian J. Agron.*, 1960–61, **5**, 256; Singh, *Allahabad Fmr*, 1959, **33**, 55; Panikkar, *Fertil. News*, 1963, **8**(8), 20; Choudhury, 114; Bour *et al.*, *Bull. Wash. agric. Exp. Sta.*, No. 504, 1948; *Sci. & Cult.*, 1958–59, **24**, 421].

Sowing—The field pea is grown either pure or often mixed with wheat, barley, oat, or mustard. Garden pea is usually grown pure. The field pea is generally broadcast at the rate of 67–90 kg. per hectare and then covered with soil by planking or harrowing. The garden pea can be sown on flat as well as raised beds, though the latter method is preferred for effecting economy in irrigation water. The width of the beds varies in accordance with the time of sowing and the type, being about 60–70 cm. in the case of dwarf and early types and 90–150 cm. for the main season crop. The seeds are dibbled 2–4 cm. deep near the edges of the bed, at a distance of 2–4 cm. for early types and 5–6 cm. for others. About 80 kg. of seed is required to plant a hectare for early types, where the seed is small and 90 kg. where it is large; in the case of main season types, 62–67.5 kg. is required. In types with wrinkled seed, the seeds are preferably soaked in water overnight before sowing, to hasten germination and ensure a uniform stand. To reduce root-rot, particularly in early sowings, seeds may be treated with Spergan or Arasan [Mehta, loc. cit.; Singh & Sikka, *Indian Fmg, N.S.*, 1954–55, **4**(9), 25; Katyal & Sabharwal, *Indian Hort.*, 1961–62, **6**(1), 15; Choudhury, 114].

Inoculation of the seed with the root nodule bacteria is recommended, particularly where peas are planted for the first time on land not previously sown to leguminous crops or where the crop is to be grown on a poor soil. Investigations on the failure of peas in *goradu* soils of Gujarat have shown, that the population of the pea rhizobia gets reduced, due to the high temperatures that obtain in these areas during summer months, so that there is insufficient nodulation in the succeeding pea crop. Inoculation of the seed with the specific bacterium is reported to be beneficial in such cases (Purewal, loc. cit.; Vyas & Prasad, *Proc. Indian Acad. Sci.*, 1960, **51B**, 242; Thompson & Kelly, 462; Katyal & Sabharwal, loc. cit.).

Cultural operations—Where the crop is irrigated, irrigation is given once in 8–10 days till the weather cools down sufficiently and less frequently thereafter. The crop should not be starved of water when the pods are developing, or during frosty weather. Interculturing can be done after each watering till the plants are fairly well grown. Tall types of garden pea grown for vegetable are provided with some support stuck upright, in between adjacent rows. Leading shoots may be pinched off to check the growth of the vine and to concentrate the energy of the plant to form full pods (Singh & Sikka, loc. cit.; Milne *et al.*, 90; Thapar, 197; Gopalaswamiengar, 545).

Diseases and Pests—A large number of fungi and bacteria have been recorded infecting field and garden peas, causing serious damages to plants, pods and seeds. In India, some of the important diseases reported are wilt, mildew and anthracnose. Wilt caused by a biotype of *Fusarium orthoceras* Appel. & Wollenw. var. *pisi* Linford [syn. *F. oxysporum* f. *pisi* (Linford), *Race 1*, Snyder & Hansen] is said to be common in Poona district, causing serious damage to garden peas. The fungus does not infect plants other than peas and all wilt-resistant American and Dutch pea types are said to have proved susceptible. As the disease is favoured by a high temperature, it is said to be more serious in warmer areas. Late sowing, avoiding sandy soils, manuring the soil liberally with cattle manure to improve its water holding capacity, and keeping the temperature of the soil low by irrigations at suitable intervals are recommended. Affected plants should be carefully dug out and burnt (*Agric. Handb., U.S. Dep. Agric.*, No. 165, 1960, 267; Sukapure *et al.*, *Indian Phytopath.*, 1957, **10**, 11; Purewal, loc. cit.; Harter *et al.*, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1735, 1957, 11; Brooks, 396).

The crop is sometimes subject to powdery mildew caused by *Erysiphe polygoni* DC. emend. Salm. This is said to be common in the mountainous and submontane tracts of Punjab; it attacks other crops like cucurbits, wheat and barley. The disease appears late in March in plains and in October in the hills. It is said to be particularly destructive if the crop is infected at the time of pod formation, considerably reducing the yield. Dusting with sulphur or spraying with ultra sulphur is said to give effective control [Purewal, loc. cit.; Paracer & Bedi, *Indian Fmg, N.S.*,

1961–62, **11**(8), 27; Vasudeva, ibid., 1956–57, **6**(7), 45; Harter *et al.*, loc. cit.; Butler & Jones, 456; Brooks, 131].

Anthracnose caused by *Colletotrichum pisi* Pat. has been reported from Maharashtra. Brown or reddish brown lesions are found on all aerial parts of the plant which are infected. Leaf and pod spot caused by *Ascochyta pisi* Lib., foot-rot caused by *A. pinodella* L. K. Jones, leaf spot caused by *Cercospora pisi-sativae* Stevenson, downy mildew caused by *Peronospora pisi* Syd., collar rot caused by *Pythium* sp., and rust caused by *Pythium* sp. and by *Uromyces fabae* (Pers.) de Bary are other diseases reported on the pea crop in this country. *Epicoccum purpurascens* Ehrenb. has also been reported on the leaves of the pea (Butler, Bisby & Vasudeva, 431; Wilson, *Poona agric. Coll. Mag.*, 1959–60, **50,** 115; *Indian J. agric. Sci.*, 1950, **20,** 107; Singh, *Curr. Sci.*, 1946, **15,** 195; Saksena, *Indian Phytopath.*, 1955, **8,** 206; Butler & Jones, 612, 616, 592).

Harvested green peas are sometimes subject to soft-rot causing yellow discolouration of the pods, the seeds within being transformed to a soft mushy mass, emitting foul odour. The causative organism is said to be intermediate between *Erwinia caratowora* (Jones) Holland and *E. aroideae* (Townsend) Holland. A variety of *Bacillus megatherium* is said to attack germinating seeds of pea, causing them to rot and disintegrate completely (Hingorani, *Curr. Sci.*, 1951, **20,** 191; Gupta *et al.*, ibid., 1959, **28,** 463).

A number of fungi, such as species of *Fusarium, Alternaria, Aspergillus, Penicillium* and *Rhizopus* found associated with the seeds, are said to be responsible for reduced germination. Treatment of seeds with Ceresan is said to have proved efficacious (Sreekantiah & Mathur, *Proc. nat. Acad. Sci. India*, 1961, **31B,** 305).

The pea crop is subject to several insect pests in the field and during storage. The pod borer, *Heliothis obsoleta* F. feeds on tender foliage and young pods. Control is obtained by spraying with 0.2 per cent DDT. The aphid, *Macrosiphum pisi* Kalt., makes its appearance when the weather starts warming up. Control is reported to be obtained by spraying with 40 per cent nicotine sulphate with soap, or with tobacco decoction, pyrethrum extract or fish oil rosin soap. It can be controlled also by spraying Malathion, rotenone or rotenone-nicotine. The leaf miner, *Phytomyza atricornis* Meigen and the pea thrip, *Thrips indicus* are usually minor pests of leaves and control is obtained with the use of 0.05 per cent wettable DDT. The weevil, *Tanymecus indicus* Fst., is said to infest the pea crop sometimes in pest form. Control is obtained by spraying with 10 per cent BHC dust. The green peas inside pods of certain late types may be attacked by caterpillars of *Etiella zinckenella* Treitsche. The eggs of the pea weevil, *Bruchus pisorum* (L.), are laid on the pod walls through which the larvae bore to infest the young peas developing inside. The adult weevils emerge from ripe unharvested or shattered peas in the field in about two months. In harvested peas—unless killed by fumigation or other treatment—the weevils remain in hibernation throughout winter, escaping when the seed is removed from storage for sowing or for use. The adult weevils which emerge in the field are able to pass the winter in hibernation in sheltered localities and come out by the time the next crop of early peas begins to bloom. Field infestation may be controlled by dusts containing rotenone, methoxychlor or DDT, applied between the appearance of the first blossoms and the first pods; this kills the adult weevils, before they have an opportunity to lay their eggs. Pea semi-loopers, *Plusia orichalcea* Fab. and *P. nigrisigna* are controlled by dusting with BHC or DDT (Crop pests and how to fight them, 74, 94; Singh & Sikka, loc. cit.; Singh & Guram, *Curr. Sci.*, 1960, **29,** 286; Trehan, *J. Bombay nat. Hist. Soc.*, 1956–57, **54,** 601; Brindley *et al.*, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1971, 1058; Joshi, S.N., *Thesis*, No. 512, *Indian agric. Res. Inst., New Delhi*, 1954).

The stored grain is liable to the attack of several bruchids. Storage in the form of broken pulse, with or without skin is recommended, as the grubs find it difficult to complete their life history in the broken grains. In the case of infestation by *Bruchus pisorum* (L.), germination tests are said to be useful in finding out the extent of injury to the seeds, as infested seeds produce abnormal seedlings. Fumigating with methyl bromide or ED/CT mixture is recommended [Chatterji, *Sci. & Cult.*, 1953–54, **19,** 305; Srivastava & Bhatia, *Indian J. Ent.*, 1958, **20,** 157; *Plant Prot. Bull., New Delhi*, 1959, **11**(1–4), 37].

Harvesting - Where the crop is sown for seed, it is harvested when the seeds are mature, the plants being cut near the ground to be threshed out later by bullocks. Picking of green peas is done when the pods are well filled with young tender peas, changing in colour from dark to light green. At this stage the seeds have attained practically full size, but have barely begun to harden. In U.S.A., U.K. and other

countries of Europe where large quantities of green peas are utilized by the canning and quick freezing industries, instruments such as the tenderometer, maturometer and texturometer are reported to be widely used, to determine the optimum stage when the crop can be harvested. The pods are removed by cutting their stalks with a pair of scissors, to avoid injury to the vines by pulling. Pods should not be left on the plants to mature as otherwise the productivity of the plant may be impaired. The pods are harvested as and when they reach the desirable stage; there may be as many as seven to eight pickings, spread over a period of 5–7 weeks. The field pea crop is ready for harvesting in Uttar Pradesh between March and April, while the several types of the garden pea are harvested in the plains from November to April, depending upon the type sown and time of planting (Singh & Sikka, loc. cit.; *Chem. & Ind.*, 1958, 486).

Yield—The average yield of field pea grown for seeds in Uttar Pradesh is about 725 kg./ha., while all-India average varies between 500 and 900 kg./ha. In U.S.S.R. and U.S.A., an average yield of 1,000–2,000 kg./ha. is reported, while in some European countries like Belgium, Netherlands and U.K., yields as high as 3,000–4,000 kg./ha. are recorded (Table 6). Some improved types, now under trial in India have shown yields up to 3,670 kg./ha. The average yield of garden pea, grown for green pods, has been estimated to range from 2,750 to 5,050 kg./ha. while in some selected types yields as high as 15,140 kg./ha. have been recorded. When field pea was grown for green fodder in admixture with oats, it gave an yield of 19,000–28,000 kg./ha. (Yegna Narayan Aiyer, 1950, 41).

TABLE 6—YIELD OF DRY PEAS (100 kg. ha.) IN SOME COUNTRIES*

Countries	1962	1963	1964	1965
Netherlands	42.8	31.6	35.4	27.7
Belgium	38.8	30.2	36.1	30.6
Ireland	31.4	30.0	28.3	30.0
U.K.	30.0	27.5	30.3	33.9
France	24.2	22.3	21.2	22.6
New Zealand	18.3	22.6	24.8	22.6
U.S.A.	16.6	17.4	18.4	20.5
Denmark	15.6	19.9	24.9	22.6
U.S.S.R.	12.2	8.3	10.8	9.2
China	8.8	8.8	9.1	9.1
India	8.8	7.7	5.2	8.3
Japan	8.6	8.9	9.7	11.3
World Average	10.5	8.6	9.9	9.4

* *Prod. Yearb. FAO*, 1966, **20**, 144.

MARKETING AND TRADE

Peas marketed fresh for canning are subject to certain standard specifications. Four grades are specified, viz. Super A, Super, Fancy and Commercial. The pods are to be packed in loosely woven gunny bags or baskets. They are generally packed in standard-size gunny bags, each containing about 50 kg. of peas. Mesh bags are said to be more suited for this purpose than double woven bags. For long distance transport, or during summer months, green peas are packed in baskets made of twigs or bamboo of a capacity of 30–50 kg. (IS: 2777-1964).

Fresh unshelled peas can be stored for about two weeks at 0° and 90–95 per cent humidity. They can also be stored in crushed ice for about 2 weeks. As the cultivation of green peas for vegetable purposes is mostly concentrated near about cities and towns or in the vicinity of road or rail heads connecting with the consuming centres, the producer markets directly a large part of the total marketable surplus. Besides the cities of Delhi, Calcutta, Lucknow and Bombay, the chief assembling and consuming centres are: Meerut, Agra, Mathura, Bareilly, Moradabad, Dehra Dun, Naini Tal, Faizabad, Varanasi, and Kanpur in Uttar Pradesh; Ranchi and Hazaribagh in Bihar; Darjeeling in West Bengal; Amritsar in Punjab and Ambala in Haryana; Jabalpur and Seoni in Madhya Pradesh; Poona and Nagpur in Maharashtra; and Bangalore in Mysore (Choudhury, 116; *Agric. Marketing India, Brochure on the Marketing of Green Peas in India, Agric. Marketing Ser.*, No. 127, 1960, 4, 15, 23; Table XIII, 27).

Small quantities of dry peas amounting to 366 tonnes in 1964–65, 411 tonnes in 1965–66 and 855 tonnes in 1966–67 have been exported from this country, the chief importing countries being Ceylon, Malaysia, Singapore and Saudi Arabia.

UTILIZATION AND COMPOSITION

Pea is esteemed primarily for the nutritional value of its seeds. Peas are consumed both in the fresh form as vegetable and in the dried form as a pulse. The shelled green peas are also utilized for preparation of canned peas, frozen peas and dehydrated peas. While in America and Europe considerable quantities are used for such processing, very small quantities of

green peas—amounting to about 1 per cent of the total production—are used in India for this purpose, though the demand for such processed peas is said to be increasing. The dried seeds of the field pea constitute the chief article of commerce. In India, it is often split, like other pulses into *dal* or in some places used for making roasted or parched pea.

Recently *Sylvia*, an introduced Sugar Pea from Sweden, has been released for cultivation. Its green, soft tender pods can be used as vegetable like French beans (Table 7), since the pods lack the thick inner membrane present in other types [*Brochure Marketing Green Peas*, 1960, 8 : Whyte *et al.*, 305 : Singh *et al.*, *Indian Fmg*, *N.S.*, 1960–61, **10**(8), 13].

The green plant as well as the pods and grains, and the hay are valued as fodder. As a green fodder, in mixture with oats, pea is said to be very favourable for milk production, having a high nutritive value (Yegna Narayan Aiyer, 1950, 41 : Whyte *et al.*, 305).

The pea plant is reported to be used sometimes as a winter green manuring crop, the average amount of green matter and nitrogen turned under being, 18,500 kg. and 67 kg., respectively per hectare (Use of Leguminous Plants, 235 : Mukerji & Agarwal, *Bull. Indian Coun. agric. Res.*, No. 68, 1950, 3 : Mirchandani & Khan, *Rev. Ser., Indian Coun. agric. Res.*, No. 6, 1953, 11, 12).

Composition—Like most other legumes, peas are rich in proteins, vitamins particularly of the B group, and minerals. Table 7 gives the chemical composition of peas and pea products. Starch is the major carbohydrate, while the sugars present are sucrose, stachyose, glucose, fructose, and galactose ; sucrose is the most important, determining the sweetness in the peas. Non-reducing sugars are reported to account for about 95 per cent of the total pea sugars ; in one particular study, up to about 50 per cent of the total sugars was found to be stachyose. During growth and ripening of peas, there is a rapid decrease in sucrose and an increase in starch and hydrolysable polysaccharides. Fully grown unripe and fully grown ripe peas contained, respectively (dry basis): sugars, 5.9, 4.1 ; starch, 32.9, 43.4 ; and cellulose, 9.6, 7.4%. After picking, the peas lose their sweetness due to a decrease in sucrose and an increase in alcohol-insoluble solids. Peas also contain pectin (2.5%, as calcium pectate) [Lachat, 16 ; Setty & Siddappa, *J. Sci. Fd Agric.*, 1961, **12,** 537 ; Shallenberger & Moyer, *J. agric. Fd Chem.*, 1961, **9,** 137 ; Jacobs, II, 1279–81 ; Cherian *et al.*, *Indian Fd Packer*, 1955, **9**(3), 25 : Winton & Winton, II, 335 ; Trehan & Ahmad, *J. sci. industr. Res.*, 1947, **6B,** 16].

Low sugar and high starch contents are regarded as characteristic of poor quality peas. In general,

TABLE 7—CHEMICAL COMPOSITION OF PEAS AND PEA PRODUCTS

	Green peas[1]	Dried peas[1]	Canned fresh peas[2]	Canned dried peas[2] (processed peas)	Frozen peas[3]	Roasted peas[1]	Split peas[3]	Sugar pea pods[1]
Moisture, %	72.0	16.0	84.0	68.0	80.3	10.1	10.0	83.3
Protein, %	7.2	19.7	4.6	7.2	5.7	22.9	24.5	3.4
Fat, %	0.1	1.1	..	..	0.3	1.4	1.0	0.2
Carbohydrates, %	15.9	56.5	5.8	16.2	12.9	58.8	61.7	12.0
Fibre, %	4.0	4.5	..	..	1.9	4.4	1.2	1.2
Ash, %	0.8	2.2	..	..	0.8	2.4	2.8	1.1
Calcium, mg./100 g.	20.0	75.0	25.0	45.0	17.0	81.0	33.0	62.0
Phosphorus, mg./100 g.	139.0	298.0	..	..	94.0	345.0	268.0	90.0
Iron, mg./100 g.	1.5	5.1	1.0	1.7	1.5	6.4	5.1	0.7
Carotene (as vitamin A), I.U./100 g.[4]	130.0	66.0	500.0	170.0	670.0	31.0	370.0	680.0
Thiamine, μg./100 g.	250.0	470.0	750.0	360.0	330.0	470.0	770.0	300.0
Riboflavin, μg./100 g.	10.0	380.0	..	..	110.0	210.0	280.0	100.0
Nicotinic acid, mg./100 g.	0.8	1.9	..	..	1.9	3.5	3.1	..
Ascorbic acid, mg./100 g.†	9.0	0	0.7	..	18.0	0	2.0	21.0

[1] Nutritive Value of Indian Foods, 63, 99, 129, 53, 89, 123 ; [2] Cherian *et al.*, *Indian Fd Packer*, 1955, **9**(3), 25 ; [3] Watt & Merrill, *Agric. Handb.*, *U.S. Dep. Agric.*, No. 8, 1950, 38 ; [4] Wu Leung *et al.*, ibid., No. 34, 1952, 25.
† Values for vitamin A and ascorbic acid are recorded to be higher in peas of foreign origin.

highly wrinkled types are characterized by high sugar and low alcohol-insoluble solids, with a predominantly amylose type of starch content. The smooth-seeded peas have comparatively low percentage of sugar and high content of alcohol-insoluble solids, and the starch contains predominantly amylopectin. In one analysis, wrinkled pea starch contained 98 per cent amylose and 2 per cent amylopectin, whereas smooth pea starch contained 30 per cent amylose and 66 per cent amylopectin. Pea starch has low viscosity and gel strength, because the granules (size, c. 35 μ; kidney-shaped or irregularly oval) are extremely resistant to swelling by hot water (Jacobs, II, 1280; Setty & Siddappa, *J. Sci. Fd Agric.*, 1961, **12,** 537; Brautlecht, 282–83; Radley, I, 283).

Peas have a high content of proteins; values up to 28 per cent or even more have been recorded in dry peas. The proteins of both field and garden peas consist principally of a globulin named legumin, with smaller amounts of another globulin vicilin and an albumin named legumelin. A protoproteose and a deuteroproteose have been isolated as minor components. The crude protein and globulin contents of the peas increase with ripeness until they reach a maximum in the fully ripe, dry seeds. The non-protein nitrogen was found to be about 25 per cent of the total nitrogen in green peas; it showed high concentration of free arginine and lysine. The percentage of non-protein nitrogen in dried peas was reported as 9.7. The following amino acids, besides all the essential amino acids, have been identified in the free form in green peas: aspartic acid, glutamic acid, tyrosine, cystine, glycine, proline and serine [Chitre *et al., J. Nutr.*, 1950, **42,** 207; Jacobs, I, 212; II, 1286–87; Schuphan & Postel, *Naturwissenschaften*, 1960, **47,** 323; Kulkarni & Sohonie, *Indian J. med. Res.*, 1956, **44,** 511; Rama Rao & Kadkol, *Food Sci.*, 1957, **6,** 154; Sah & Gupta, *Agra Univ. J. Res.* (*Sci.*), 1960, **9,** 191; *Chem. Abstr.*, 1959, **53,** 9510].

The biological values and digestibility coefficients of pea proteins determined at different levels of intake are given in Table 8. The proteins of immature raw peas are reported to have poor biological values. The effect of maturity on the nutritive value of pea proteins is, however, a subject of controversy. Table 9 shows the essential amino acid make-up of the total proteins of peas compared to whole egg protein. Methionine and cystine are the main limiting amino acids, showing a deficit of about 66 per cent as compared with proteins of whole egg; one sample of peas was found to contain no methionine. Pea proteins are generally good in leucines, lysine and threonine. Supplementary relationships have been observed between the proteins of peas and those of cereal germs or meat (Kuppuswamy *et al.*, 36–38; Chitre *et al., J. Nutr.*, 1950, **42,** 207; Armbruster & Murray, ibid., 1951, **44,** 205; Altschul, 309; Zarkadas *et al., J. Sci. Fd Agric.*, 1965, **16,** 734; Bagchi *et al., Ann. Biochem.*, 1955, **15,** 149).

There are numerous published records, with some conflicting statements, on the effect of processing on the pea proteins. It is generally believed that the nutritive value of field pea proteins is impaired by heat, baking, autoclaving, and canning; this can be corrected by supplementation with methionine or cystine. It appears that the destruction of cystine is

TABLE 8—NUTRITIVE VALUE OF PEA PROTEINS

	Protein content	Level of feeding	Biological value	Digestibility coefficient
Field peas, green[1]		10	57.3	91.6
Field peas, dried[2]		5	69.0	..
		10	62.0	70.0
Field peas, dried[3]	27.1	10	48.0	91.0
		15	41.0	89.0
Field peas, parched[4]			78.2	83.9

[1] Murray, *J. Nutr.*, 1948, **35,** 257; [2] Niyogi *et al., Indian J. med. Res.*, 1930–31, **18,** 1217; [3] Basu *et al.*, ibid., 1936–37, **24,** 1001; [4] Acharya *et al.*, ibid., 1942, **30,** 73.

TABLE 9—ESSENTIAL AMINO ACID COMPOSITION OF PEA PROTEINS (g./16g. N)

	Green mature peas[1]	Dried peas (pulse)[2]	Dried peas (pulse)[3]	Canned mature peas[1]	Egg, whole[4]
Arginine	7.3	17.7	13.4	8.8	6.4
Histidine	1.2	2.7	2.1	1.4	2.1
Methionine	0.8	1.3	0.8	1.0	4.1
Lysine	3.2	11.4	8.9	3.1	7.2
Valine	3.3	7.8	6.5	3.8	7.3
Phenylalanine	3.0	5.8	4.6	3.9	6.3
Tryptophan	0.7	0.7	0.3	1.0	1.5
Leucine	7.2	10.9	9.5	8.8	9.2
*Iso*leucine	4.7	8.4	7.1	4.8	8.0
Threonine	3.2	4.9	4.2	3.3	4.9

[1] Chitre *et al., J. Nutr.*, 1950, **42,** 207; [2] Ramachandran & Phansalkar, *Indian J. med. Res.*, 1956, **44,** 501; [3] Chatterjee *et al., Food Res.*, 1956, **21,** 569; [4] Block & Mitchell, *Nutr. Abstr. Rev.*, 1946–47, **16,** 249.

the primary factor leading to methionine deficiency in cooked peas. The effect of canning on the biological value is reported to be influenced by the maturity and *p*H of the peas. According to a few reports, the nutritive value of peas is unaffected by heat or canning. Parching is stated to improve the biological value of proteins of dry peas, whereas germination decreases the biological value. Protein breakdown is believed to occur in peas, with increased formation of amides and ammonia, during germination in air and also on prolonged soaking in water. The presence of a trypsin inhibitor which is partially or wholly destroyed by heating or autoclaving is reported in peas; however, some record its complete absence (Altschul, 93, 95, 309; Woods *et al., J. Nutr.*, 1943, **26,** 327; Murray, ibid., 1948, **35,** 257; Armbruster & Murray, ibid., 1951, **44,** 205; Schneider & Miller, ibid., 1954, **52,** 581; Richardson, ibid., 1948, **36,** 451; Chitre *et al.*, ibid., 1950, **42,** 207; Acharya *et al., Indian J. med. Res.*, 1942, **30,** 73; Chattopadhyay & Banerjee, ibid., 1953, **41,** 185; Kuppuswamy *et al.*, 37–38; Sohonie & Bhandarkar, *J. sci. industr. Res.*, 1955, **14C,** 100).

Green peas are considered as one of the best foods for supplying adequate quantities of vitamins and minerals. They contain: vitamin A, 600–3,300 I.U.; thiamine, 350–800 μg.; riboflavin, 50–250 μg.; and ascorbic acid, 15–30 mg./100 g. A sample of peas showed as high a value as 85 mg./100 g. of ascorbic acid. The values reported for vitamin A and ascorbic acid for Indian samples are generally lower than those reported for samples from elsewhere. Early small-seeded types are richest in ascorbic acid and in the same type smaller peas have higher concentrations of the vitamin than the larger ones. Cooking especially if prolonged, may affect the nutritive value of peas, particularly the ascorbic acid value; thiamine content also may be affected. A loss of about 20 per cent of carotene and 33 per cent of ascorbic acid on cooking has been reported [Lachat, 16; Thorpe, IX, 255; Todhunter & Robbins, *Bull. Wash. agric. Exp. Sta.*, No. 408, 1941, 5, 17–18; Chatfield, *FAO nutr. Stud.*, No. 11, 1954, 35; Sherman, 622, 691; Maqsood Ali *et al., Pakist. J. Sci.*, 1963, **15,** 204; Kibe & Mohapatra, *Poona agric. Coll. Mag.*, 1965, **55**(1–4), 5].

Dried pea, like other pulses, is a good source of vitamins of the B group. It contains: thiamine, 0.54–0.93 (up to 1.4); riboflavin, 0.15–0.37; nicotinic acid, 0.8–1.6; pyridoxine, 0.14; inositol, 150; folic acid, 51; pantothenic acid, 2.1; biotin, 8.2; and choline, 197–280 mg.; and vitamin B_{12}, 0.36 μg./100 g. Other vitamins present in dried peas are: carotene, 1.2–1.5; ascorbic acid, 4.2–6.8 (dehydroascorbic acid, 0.1–0.7); tocopherol, 2.2; and vitamin K, 0.15 mg./100 g. During germination, there is a marked increase in the concentration of all the vitamins except folic and pantothenic acids (Sherman, 691; Chattopadhyay *et al., Indian Pharm.*, 1949–50, **5,** 121; Nandi & Banerjee, ibid., 1949–50, **5,** 13, 63, 202; Banerjee *et al., Food Res.*, 1955, **20,** 545; 1954, **19,** 134; Chattopadhyay & Banerjee, ibid., 1951, **16,** 230; 1952, **17,** 402; Ahmad *et al., Indian J. med. Res.*, 1953, **41,** 441; Chattopadhyay & Banerjee, *Science*, 1951, **113,** 600; Rohatgi *et al., J. Nutr.*, 1955, **56,** 403).

Peas are a good source of potassium and phosphorus. Wrinkled types have generally higher ash and phosphate contents and lower acid-base balance than the smooth-seeded types. Green peas and dried peas contain, respectively: calcium, 20, 75; phosphorus, 139, 298; iron, 1.5, 5.1; sodium, 7.8, 20.4; potassium, 79, 725; copper, 0.23, 0.85; sulphur, 95, 189; and chlorine, 20, 59 mg./100 g. Trace elements present in peas include iodine (0.9 μg./100 g. in green peas), cobalt, molybdenum, zinc, manganese, barium, aluminium, arsenic, boron, lithium and nickel. On germination, the available iron content of pea increases significantly; also, the phytin phosphorus decreases considerably with an increase in water-soluble inorganic phosphorus content [Jacobs, II, 1287; Setty & Siddappa, *J. Sci. Fd Agric.*, 1961, **12,** 537; Nutritive Value of Indian Foods, 89, 99; Datta & Datta Biswas, *Indian J. agric. Sci.*, 1951, **21,** 93; Ghosh & Mazumder, *Indian J. Phys.*, 1950, **24**(2), 67; Thorpe, IX, 255; Wehmer, I, 564; Singh & Banerjee, *Indian J. med. Res.*, 1955, **43,** 497; Belavady & Banerjee, *Food Res.*, 1953, **18,** 223].

The following enzymes have been reported in peas: sucrase, diastase, protease, peptidase, glutamic acid and aspartic acid decarboxylases, pyruvic carboxylase (optimum *p*H 5.1), triphosphate dehydrogenase, and a phosphorylase. Phytase and phosphatase are present in germinated peas; the former is absent in the ungerminated pulse. Seedlings show glutamic acid dehydrogenase activity; they contain asparagine (Jacobs, II, 1282, 1286; Kulkarni & Sohonie, *Nature, Lond.*, 1956, **178,** 925; Ambe & Sohonie, *J. sci. industr. Res.*, 1959, **18C,** 135; *Chem. Abstr.*, 1958, **52,** 3931; Belavady & Banerjee, loc. cit.; Damodaran & Nair, *Biochem. J.*, 1938, **32,** 1064; Wehmer, I, 564).

Dried peas yield 1–2 per cent of a pale golden yellow fatty oil having the following constants: sp. gr.$^{15.5°}$, 0.919; $n^{35°}$, 1.4766; solid. p., −12°; sap. val., 184–85; iod. val., 106; and unsapon. matter. 1.0–1.5%. The oil contains glycerides of palmitic, oleic and probably arachidic acids; linoleic and non-conjugated mono-, di-, and tri-ethenoic acids have also been reported. The unsaponifiable matter contains β-amyrin, β-sitosterol and two unidentified hydrocarbons. Lecithin, cephalin and phosphatidyl inositol are present in the oil (Thorpe, IX, 255: Mensier, 460; Wehmer, I, 564: *Chem. Abstr.*, 1963, **59**, 15505: Ganguly & Bhattacharyya, *J. Indian chem. Soc.*, 1957, **34**, 247; Wagenknecht, *Science*, 1957, **126**, 1288).

Pea oil when given to women once a month, in the form of intramuscular injections, showed promise of preventing pregnancy. The active principle responsible for the antifertility effect has been found to be *m*-xylohydroquinone which appears to act by interfering with the working of progesterone. Trials on women with capsules (twice a month) containing 300–350 mg. of *m*-xylohydroquinone for variable periods have shown a 50–60 per cent reduction in the pregnancy rate. The drug is non-toxic and has no side effects. In trials on men, the drug was found to bring about a 50 per cent reduction in the number of spermatozoa, which reverted to the normal count in about 4 days after the withdrawal of the drug. According to an investigation in the U.S.A. on the contraceptive efficacy of the pea oil, women who were administered the oil became pregnant in 50 per cent of the cases [Sanyal, *East. Pharm.*, 1961, **4**(37), 41; *Bull. Calcutta Sch. trop. Med.*, 1962, **10**, 85; *Indian J. Pharm.*, 1962, **24**, 163: Dandiya & Varma, *East. Pharm.*, 1966, **9**(100), 47].

Peas contain appreciable quantity of saponin. The white, green and black types of peas show a haemagglutinating activity against rabbit, rat and the different groups of human red blood cells; heating or autoclaving of the pulse is found to remove the activity completely. A cardiolipin-like substance named pea-lipin, whose antigens are reactive in flocculation tests with syphilitic sera, has been reported in peas. Peas yield an antifungal compound named pisatin ($C_{17}H_{14}O_6$, m.p. 61°) which is formed on pea pods inoculated with either facultative or obligate plant pathogens. The seed coat of field peas contains a fungistatic substance ($C_{21}H_{22}O_{10}N.3H_2O$), probably a nitrogen-containing anthocyanidin. Among the other components reported in peas are: the carotenoids xanthophyll, neo-β-carotene U, neo-β-carotene B and β-carotene, quercitrin, α-amino adipic acid, and trigonelline (Biswas, *Sci. & Cult.*, 1943–44, **9**, 165; Huprikar & Sohonie, *J. sci. industr. Res.*, 1961, **20C**, 82; *Chem. Abstr.*, 1962, **56**, 1771; Mitra & Ghosh, *Ann. Biochem.*, 1961, **21**, 181; Cruickshank & Perrin, *Nature, Lond.*, 1960, **187**, 799; Perrin & Bottomley, ibid., 1961, **191**, 76: *Chem. Abstr.*, 1953, **47**, 8838: 1962, **57**, 5022; Sadana & Ahmad, *J. sci. industr. Res.*, 1947, **6B**, 47; Ganju & Puri, *Indian J. med. Res.*, 1959, **47**, 563; Manske & Holmes, I, 176).

On storage, the alcohol-insoluble content increases probably at the expense of sucrose and hence a definite change in flavour. In both shelled and unshelled peas stored at 25°, the most significant changes are the decrease in sucrose and increase in starch contents; these changes are more rapid in the shelled peas (Jacobs, III, 1831: II, 1284).

PEA PRODUCTS

Canned peas—Canning is done mainly of freshly harvested and shelled green peas. Wrinkled as well as smooth peas are widely used for canning purposes, though the former are better flavoured and are preferred. Smooth seeded types exhibit uneven texture, mealiness, hard seededness and splitting and hence are not generally suited for canning. A good canning type means well filled green pods containing seeds of medium bold size, tender texture and possessing sweet and not starchy taste. In the case of over-mature peas, the canned product has a tendency to gelatinize, which can be minimized by decreasing the proportion of peas to brine filled in the cans. Sometimes canned peas develop a black flaky deposit, probably of the sulphide of the can metal; use of cans lined with C-enamel has been recommended [Cruess, 259–73, 303; Jain & Mukherjee, *Indian Hort.*, 1965–66, **10**(2), 51: Girdhari Lal *et al.*, 73–74: von Loesecke, 1942, 132; *Brochure Marketing Green Peas*, 1960, 21: Siddappa & Das, *Indian Fd Packer*, 1953, **7**(10), 9].

Canned peas have a greenish yellow colour. Ordinarily, only drained peas from the can are eaten, the liquid being rejected, although in cooked green peas the liquor is prized for its sweetness and delicate flavour. Analysis of canned peas is given in Table 7 [Cruess, 259; Cherian *et al.*, *Indian Fd Packer*, 1955, **9**(3), 25].

Blanching removes the characteristic raw taste and odour of the peas. However, some of the valuable

nutrients are lost in blanching, more in water- than in steam-blanching. There is no loss of carotene and riboflavin on steam-blanching, but on blanching in boiling water, there is a loss of 5.3 and 18.3 per cent respectively of these vitamins. Thiamine retention of samples blanched in steam and in boiling water was 96.4 and 86.0 per cent respectively; the corresponding values for ascorbic acid retention were 76.0 and 69.1 per cent respectively. Increase in blanching time affected the ascorbic acid content more adversely than did the increase in blanching temperature (Cruess, 266–67; Dhopeshwarkar & Magar, *J. sci. industr. Res.*, 1954, **13B**, 848: Blanck, 374; Malakar & Banerjee, *Ann. Biochem.*, 1957, **17**, 27).

Dried peas also can be canned after they have been soaked in water. Such processed peas are cheaper than fresh canned peas and can be canned out of season also. Analysis of canned dried peas is given in Table 7 (*Bull. cent. Fd technol. Res. Inst., Mysore*, 1954–55, **4**, 140: Setty & Siddappa, *J. Sci. Fd Agric.*, 1961, **12**, 537).

Canned peas can normally be stored at room temperatures for about a year. Storage for one year at room temperature showed an increase in sugar content and a considerable loss of thiamine (54%) and nicotinic acid (48.9%); the ascorbic acid, carotene and riboflavin contents remained practically unaffected (*Brochure Marketing Green Peas*, 1960, 21; Dhopeshwarkar & Magar, *J. sci. industr. Res.*, 1955, **14C**, 27).

Canning is mostly done in Uttar Pradesh, the biggest producer of green peas, and also in Maharashtra where there are a number of major canning factories. Though the army is the largest bulk purchaser of canned peas, the civilian demand is also on the increase. It is planned to set up automatic pea canning plants in order to reduce the prices (*Brochure Marketing Green Peas*, 1960, 18–19).

Dehydrated peas—For the preparation of dehydrated peas, the wrinkled types are preferred to the starchy smooth ones. The peas should be even more tender than the canning types. The fresh green peas are blanched in water (at 94–99°) and then dehydrated in a suitable dehydrator. To obtain a good quality product, the individual peas have to be pricked prior to blanching. Pricking is a rather difficult operation and is done mechanically. Blanching of the green peas for 5–6 minutes in a 5 per cent boiling salt solution containing sodium bicarbonate (0.1–0.15%) and magnesium oxide (0.1%) and grading for maturity followed by sulphitation for 30 minutes (in 0.5% solution of potassium metabisulphite) and dehydration (at 60–65°) yields a product possessing satisfactory reconstitution and cooking characteristics. Sulphitation improves the colour, general appearance and storage behaviour of the peas. Dehydrated peas packed in tin cans or aluminium foil containers are found to keep well for over a year. The cooking time of dehydrated peas decreases with the maturity of the peas treated. Compared to

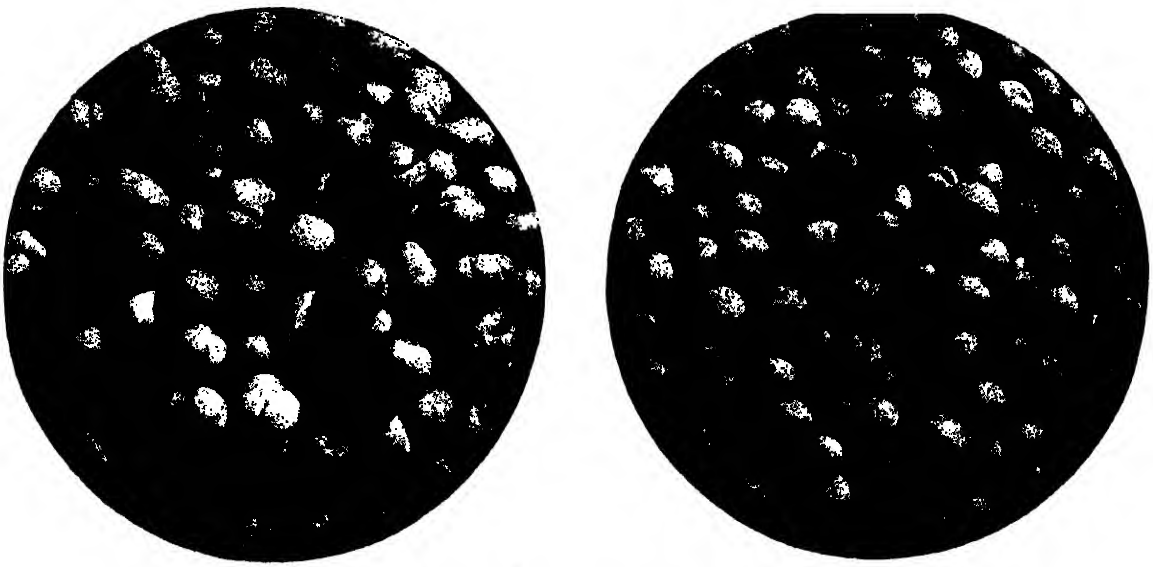


FIG. 46—PISUM SATIVUM—PARCHED AND UNPARCHED SEEDS

canned peas, the dehydrated product has the advantages, like the natural green colour, better flavour and desirable texture. Dehydration of green peas has been taken up on a commercial scale at Ghaziabad (Uttar Pradesh) (*Brochure Marketing Green Peas*, 1960, 17 ; Bhatia *et al., Indian J. Technol.*, 1963, **1,** 250 ; Jain & Choudhury, *Indian J. Hort.*, 1963, **20,** 129 ; Jain & Mukherjee, loc. cit.).

Frozen peas—Peas are one of the most important of the frozen pack vegetables in U.S.A. and U.K. Some trials have been made in this country for the manufacture of frozen peas on an experimental basis by a firm in Bombay. Tender, sweet, deep green peas after blanching and quality separation are filled into cartons, sealed and quick-frozen at $-34°$ to $-40°$ and stored in fibre board cases at or below $-20°$. Analysis of frozen peas is given in Table 7. Frozen peas deteriorate quite rapidly (*Brochure Marketing Green Peas*, 1960, 10 ; von Loesecke, 1942, 478).

Parched peas (HINDI—*Bhuna matar ;* TAM.—*Varutha pattani*)—In India, considerable quantities of field pea are roasted or parched and sold for direct consumption. Composition of roasted pea is given in Table 7.

Split peas (HINDI—*Matar dal ;* TAM.—*Pattani paruppu*)—Large quantities of field pea are also used for preparation of split pea or *dal.* This product is mostly from peas produced in non-irrigated areas of Punjab, Delhi, Uttar Pradesh, Bihar and Madhya Pradesh. In South India, it is consumed in the form of flour (*Basan*), used in various confectionery preparations. Composition of split pea is given in Table 7 (Joshi, S. N., *Thesis*, No. 512, *Indian agric. Res. Inst., New Delhi*, 1954).

The pea seeds are said to cause dysentery when eaten raw. The flour of the seed is reported to be emollient and resolvent and is applied in the form of cataplasm. The flour is also used in dusting powders and pills. A poisonous acid similar to that found in *Lathyrus sativus* and causing similar symptoms when fed to monkeys is said to have been isolated from the seeds. An extract obtained from peas is reported to have been effective in lowering blood sugar level and in reducing alimentary hyperglycaemia in experimental animals (Chopra, Nayar & Chopra, 195 ; Kirt. & Basu, I, 772 ; Steyn, 87 ; Mukerji, *J. sci. industr. Res.*, 1957, **16A,** suppl., 1–16).

Pea fodder—Peas can be used as an excellent though expensive feed. They should be fed after grinding. Peas are satisfactory for dairy cattle, horses, and pigs on pasture when fed as the only protein supplement. They produce firm flesh in sheep. Cull peas consisting of split, small or damaged peas may be used instead of the high grade peas (Morrison, 495–96 ; Lander, 389).

The green plant, empty pods and hay may all be used as feeds (Table 10). A combination of field peas and oats, if cut early and well cured, makes hay comparable to lucerne, for fattening lambs : this combination also makes satisfactory silage. The green vine is good in protein, which has the following essential amino acid make-up: arginine, 5.4 ; histidine, 1.8 ; lysine, 5.8 ; phenylalanine, 6.7 ; methionine, 1.8 ; threonine, 4.5 ; leucine, 8.7 ; isoleucine, 5.1 ; and valine, 6.1 g./16 g. N. The waste coming from pea canneries consists of the vines and empty pods and may be used as feed for dairy cows, cattle and sheep, either fresh or as hay or silage. The silage, though possessing a strong odour, does not spoil the flavour of milk (Morrison, 328–29 ; Kuppuswamy *et al.*, 234 ; Cruess, 263, 757).

The young foliage of the garden pea is reported to be sweet and used as a vegetable among the Burmese. The leaves contain the enzymes invertase and diastase, carotene (177 mg./100 g., dry basis), nicotinic acid (0.63 mg./100 g.), and trigonelline. The leaf meal is rich in protein (23.6%) (Burkill, II, 1758 ; Wehmer, I, 563 ; Sen Gupta, *Indian J. appl. Chem.*, 1958, **21,** 45 ; Kuppuswamy *et al.*, 234).

TABLE 10—FEEDING VALUE OF PEA

	Dry matter %	Protein %	Fat %	Carbo-hydrates %	Fibre %	Ash %	Calcium %	Phosphorus %	Dig. protein %	Total dig. nutrients %	Nutr. ratio
Plant (dough stage)[1]	23.9	4.0	0.6	13.0	5.4	0.9	0.28	0.06	..	..	..
Hay[2,a]	..	10.9	1.9	50.3	29.2	7.7	1.13	0.21	..	..	..
Silage[3]	27.9	3.8	1.2	12.5	7.8	2.6	0.38	0.08	3.0	18.1	5.0
Seeds, dry[3]	90.7	23.4	1.2	57.0	6.1	3.0	0.17	0.50	20.1	77.9	2.9

[1] Lander, appx I ; [2] Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1964, appx.I, 80 ; [3] Morrison, 1060, 1040.
[a] Values on dry matter basis.

Pitanga — *see* **Eugenia**

Pitch — *see* **Pinus**

Pitch, Burgundy — *see* **Picea**

Pitchblende — *see* **Uranium Ores**

Pitcher Plant — *see* **Nepenthes**

PITHECELLOBIUM Mart. (*Leguminosae; Mimosaceae*)

A genus of trees and shrubs distributed in the tropics, chiefly in Asia and America. About 10 species occur in India.

This genus has been split up into several smaller genera and most of the Indian species have been referred to *Abarema* Pittier. Recently, however, these genera have been reduced to subgeneric status, as sections (Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 1–122; Mohlenbrock, *Reinwardtia*, 1961–64, **6**, 443).

***P. clypearia** Benth. syn. *P. angulatum* Benth.; *P. montanum* Benth.; *P. subacutum* Benth. GRASSHOPPER TREE

Fl. Br. Ind., II, 305–06; Fl. Assam, II, 172; Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 42, Fig. 28; Corner, Pl. 109.

LEPCHA—*Takpier, takpyit*; ASSAM—*Bhasahu, thorekana*; LUSHAI—*Ardahpui*.

A shrub or small to medium-sized tree with acutely angled branches found in the eastern Himalayas, Sikkim, Khasi, Mishmi and Lushai hills of Assam up to an altitude of 1,200 m., Manipur and in the Andaman and Nicobar Islands. Bark smooth, dark brown or grey; leaves bipinnate: pinnae 5–12 pairs; pinnules variable in shape and size; flowers white or yellowish white, fragrant; pods spirally twisted up to 20.0 cm. long and 1.8 cm. broad; seeds 8–10, purplish or bluish black. The plant is grown as an ornament (Bailey, 1947, III, 2652).

The bark (tannin, up to 27.7%) is used for tanning fishing-nets and for washing hair. The leaves are used alone or along with the fruits of *Terminalia chebula* Retz. for dyeing cotton black. The leaves are reported to be poisonous to cattle. They are used in poultices as a remedy for sore legs, swellings, cough, chickenpox and smallpox. The ashes of the leaves mixed with coconut oil are reported to be used in skin affections (Burkill, II, 1759; Baens *et al., Philipp. J. Sci.*, 1934, **55**, 177; Fl. Assam, II, 173).

The wood is soft and light. It is used for making sheaths of weapons. Analysis of wood for pulp gave: lignin, 27.5; holocellulose, 56.3; pentosan, 15.7; and ash, 0.4% (Burkill, II, 1759; Monsalud & Nicolas, *Philipp. J. Sci.*, 1958, **87**, 119).

P. dulce Benth. QUAMACHIL, MADRAS THORN, MANILA TAMARIND

D.E.P., VI(1), 281; Fl. Br. Ind., II, 302; Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 8; Brown, II, 295, Fig. 32.

HINDI—*Vilayati babul, vilayati imli, jangle jalebi*; BENG.—*Dekhani babul*; MAR.—*Vilayati chinch*; TEL.—*Simachinta*; TAM.—*Kodukkaapuli*; KAN.—*Kottampuli, seemae hunase*; MAL.—*Korukkapuli*.

A small to medium-sized, evergreen, spiny tree, up to 18 m. in height, native of tropical America, and cultivated throughout the plains of India, and in the Andamans. Bark smooth, grey with yellowish white lenticels; leaves bipinnate: pinnae 2; pinnules 2 in each pinna, obliquely ovate-oblong, 1–4 cm. long; flowers in dense heads *c.* 1 cm. in diam., small, white; pods curved or twisted, constricted, reddish brown, 10.0–15.0 cm. long and 1.0–1.5 cm. broad; seeds 6–10, shining black, enveloped in pink to whitish, pulpy aril.

Quamachil is a hardy tree and grows even in waste and denuded lands, pure sandy soil and on sea coast with its roots in brackish or salt water. It can withstand a good deal of shade and is resistant to drought. It reproduces easily by seeds or cuttings.

Quamachil is mostly grown in India for hedges and for fuel. It is very suitable for both these purposes, as it has a fast rate of growth, coppices vigorously and can withstand any amount of pruning, lopping or browsing by animals. For hedges, seeds may be sown at site in two rows 30 cm. apart with a spacing of 15 cm. By regular trimming, almost impenetrable fences can be grown. Quamachil is also grown as a shade or roadside tree and for ornament because of its handsome foliage and curious pods. The tree is affected by leaf spot diseases (*Phyllosticta inga-dulcis* Died. and *Colletotrichum* spp.) and a number of defoliating and boring insect pests. It has also been recorded as a host of lac insect. Some trees bearing lac encrustations of the *rangeeni* strain up to 45 cm. long have been observed at Hoshiarpur in the Punjab and it has been suggested that the tree

* Kostermans, while considering the two species *P. clypearia* and *P. angulatum* as distinct, states that he is unable to take a decision regarding their conspecificity. Following Craib, the two species are, however, considered conspecific here, as their economic uses are inseparable (Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 1–122; Craib, I, 557).

FIG. 47—PITHECELLOBIUM DULCE—FRUITING BRANCH

may prove useful for the cultivation of lac [Gamble, 309; Troup, II, 485; Use of Leguminous Plants, 236; Mitchell, *Malay. For.*, 1964, **27,** 96; Gopalaswamiengar, 184; *Indian J. agric. Sci.*, 1950, **20,** 107; Agarwal & Beliram, *J. Indian bot. Soc.*, 1960, **39,** 351; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 40; Malhotra, *Indian For.*, 1964, **90,** 366].

The pods of quamachil (wt., 10–20 g.) are used as fodder for cattle, sheep, goats and other livestock. They consist of 50.3 per cent pulp, 25.3 per cent seed, and 24.4 per cent peelings. The pulpy aril of ripe seeds is sweet and edible. In Mexico, the aril is reported to be used in the preparation of a beverage similar to lemonade. Analysis of the aril (from Maharashtra) gave the following values: moisture, 77.9; protein, 0.7; fat (ether extr.), 0.6; fibre, 1.2; carbohydrates, 19.9; and mineral matter, 0.7%; calcium, 13.0 mg.; phosphorus, 54.0 mg.; iron, 1.4 mg.; thiamine, 222 μg.; riboflavin, 59 μg.; nicotinic acid, 0.36 mg.; and ascorbic acid, 120 mg./100 g. The essential amino acids found in the aril were: valine, 143; lysine, 178; phenylalanine, 41; and tryptophan, 26 mg./100 g. A sample of ripe aril (60% of the pod) from Hyderabad contained the following mineral constituents: total mineral matter, 1.0%; calcium, 21.0; magnesium, 40.0; phosphorus, 58.0; iron, 1.1; sodium, 3.7; potassium, 377.0; copper, 0.6; and sulphur, 109.0 mg./100 g. The sugars in the aril consist mostly of glucose. Pectin is present to the extent of 0.96 per cent, as calcium pectate. Hexacosanol and a sterol-glucoside (m.p. 282–86°) have been isolated from the aril (Benthall, 222; Gamo & Cruz, *Philipp. J. Sci.*, 1957, **86,** 131; Gonzalez *et al.*, ibid., 1963, **92,** 28; Record & Hess, 309; *Rep. Dep. Nutr. Govt. Bombay*, 1957, 26, 30; Balasubramanian *et al.*, *Indian J. med. Res.*, 1962, **50,** 779; Nigam *et al.*, *J. pharm. Sci.*, 1963, **52,** 459).

The seeds are stated to be eaten raw or in curries. They contain: moisture, 13.5; protein, 17.6; fat, 17.1; crude fibre, 7.8; starch, 41.4; and ash, 2.6%. On alcoholic extraction, the seeds yield a saponin (m.p. 175–81°, yield *c.* 2.4%), a sterol-glucoside (m.p. 276–78°), a flavone (m.p. 298–306°), and lecithin (0.7%). On hydrolysis, the saponin gives a sapogenin ($C_{28}H_{44}O_4$, m.p. 207–08°) which has been provisionally named pithogenin and appears to be a steroid genin. The saline extract of the seeds showed a haemolytic agglutinating reaction with human blood [Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 98; Kesava-Menon, *J. Soc. chem. Ind., Lond.*, 1910, **29,** 1428; Nigam *et al.*, loc. cit.; Schertz *et al.*, *Econ. Bot.*, 1960, **14,** 232].

The fatty oil from the seeds is a yellowish white viscous liquid, resembling kapok seed oil in its physico-chemical properties and groundnut oil in its fatty acid composition. The characteristics of the oil are: sp. gr.$^{30°}_{4°}$, 0.9044; $n_D^{29°}$, 1.4546; sap. val., 185.3; iod. val., 80.7; acid val., 1.2; thiocyanogen val., 56.0; and unsapon. matter, 0.6%; fatty acid composition: saturated acids, 24.3; oleic, 51.1; and linoleic, 24.0%. The seeds on solvent extraction gave 20 per cent of a greenish oil, which after refining and bleaching showed the following characteristics: colour (Lovibond, 1 cm. cell), 1.1 Y; sp. gr.$^{26°}$, 0.9064; n_D^{26}, 1.4635; iod. val. (Wijs), 68; acid val., 0.2; sap. val., 183.0; and unsapon. matter, 1.07%. Quamachil seed oil is suitable for edible purposes, and for soap manufacture. It can also be used as a substitute for kapok seed and groundnut oils. The meal, left after the extraction of oil from the seeds, has a high protein content (29.7%) and may be used as an animal feed (Kesava-

Menon, loc. cit.; Gamo & Cruz, loc. cit.; Nigam *et al.*, loc. cit.).

The bark contains tannin (up to 37%) of a catechol type, the content of which varies according to the age of the plant. The usual recorded ranges of values for Indian samples are as follows: moisture, 8–12; tannin, 22–28; and non-tans, 10–15%. Acetone extract of the bark is reported to consist mostly of 3,4,7,3′,4′-pentahydroxyflavan—a compound which combines the properties of both leucoanthocyanidin and phlobotannin. A 5:1 blend of quamachil and myrobalan bark is found to be a suitable tanning material for sole leather. Quamachil bark can also be advantageously used as a substitute for wattle bark in various compositions of blended tannage for tanning sole leather and kips. Like wattle bark, liquor of quamachil bark produces leathers which are light in colour. The bark also contains a yellow dye and 1.5 per cent of pectin. It is reported to contain irritant principles which cause dermatitis and inflammation of the eyes. It has been reported to be used as an astringent in dysentery, and as a febrifuge [Baens *et al.*, *Philipp. J. Sci.*, 1934, **55,** 177; Udaya Varma *et al.*, *Bull. cent. Leath. Res. Inst., Madras*, 1956–57, **3,** 7; 1957–58, **4,** 479; Kedlaya *et al.*, *Leath. Sci.*, 1963, **10,** 305; Rajadurai, ibid., 1963, **10,** 340; Scharpenseel & Vicario, *Araneta J. Agric.*, 1956, **3**(4), 51; Hocking, 175; Morton, *Proc. Fla St. hort. Soc.*, 1962, **75,** 484; Kirt. & Basu, II, 947].

The leaves serve as fodder for sheep, goats, horses and cattle. They have the following composition (on dry basis): crude protein, 29.0; ether extr., 4.4; crude fibre, 17.5; N-free extr., 43.6; ash, 5.6; calcium, 1.14; and phosphorus, 0.35%. The leaves may be used for green manuring; their manurial value has been reported as follows (on dry basis): nitrogen, 4.91; phosphorus (P_2O_5), 0.78; lime (CaO), 1.04; and potash (K_2O), 2.67%. They have also been reported to possess astringent, emollient and abortifacient properties. An insulin-like principle has been reported in the leaves. The flowers are visited by bees and yield a good quality of honey. The tree yields a gum which forms a good mucilage [Benthall, 222; *Jt Publ. imp. agric. Bur.*, No. 10, 1947, 210; Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18,** 362; Quisumbing, 424; Garcia, *Philipp. J. Sci.*, 1944, **76**(3), 3; Record & Hess, 309].

The wood of quamachil is reddish brown in colour, somewhat lustrous, straight- to irregular-grained, rather fine-textured, hard, heavy (wt., 641 kg./cu.m.) and strong, but brittle. It is difficult to cut, but can be finished to a smooth surface. It is used for general construction, packing cases, fence posts, cart-building and agricultural implements. It is an excellent fuelwood—calorific value, 5,177–5,580 cal. (Record & Hess, 309; Khan, 164; *Indian For.*, 1948, **74,** 279).

P. monadelphum Kosterm. syn. *P. bigeminum* auct. non Mart.; *P. gracile* Bedd.

D.E.P., VI(1), 281; Fl. Br. Ind., II, 303; Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 50, Fig. 32; Talbot, I, Fig. 284.

HINDI—*Kachlora*; TAM.—*Kal pakku*; KAN.—*Kodakonde, kokke*; MAL.—*Muthakolappan*.

LEPCHA—*Tikpi-kung*; ASSAM—*Bhachahu, moj*; LUSHAI—*Ardahte*; KHASI—*Dieng-yap-yar*.

A small to medium-sized tree found in the eastern Himalayas, Khasi, Jaintia, and Lushai hills of Assam up to an altitude of 1,800 m., and in the western ghats up to an altitude of 900 m. Bark smooth, thin, brown; leaves bipinnate: pinnae 1–2 (rarely 3) pairs: pinnules elliptic-lanceolate or ovate-oblong; flowers in heads, yellowish white, small; pods flat, twisted, reddish brown, up to 15.0 cm. long and 2.5 cm. broad; seeds 5–8, sub-orbicular, *c.* 1.25 cm. in diam., black.

The bark contains 0.8 per cent of a toxic alkaloid, pithecolobine ($C_{22}H_{46}O_2N_4$), which is fatal to fish in a dilution of 1:400,000; it also contains a saponin. A decoction of leaves is said to be used as an external application in leprosy and as a stimulant for the growth of hair. The active principle of the leaves is reported to be a mixture of two unidentified acids; the leaves also contain saponins and traces of an essential oil. Seeds, after repeated boiling and discarding of water, are used as a condiment in Burma. They are poisonuos and produce abdominal pains and violent and persistent vomiting when eaten uncooked; they contain pithecolobine. The seeds are reported to be prescribed in diabetes mellitus (Merck Index, 825; Wehmer, I, 484; Orr & Weisner, *Chem. & Ind.*, 1959, 672; Chopra *et al.*, I, 344; Chakravarti & Ganapati, *J. Annamalai Univ.*, 1932, **1,** 181; Kirt. & Basu, II, 946).

The tree yields a brownish, soft and light wood (wt., 352 kg./cu.m.), which is neither durable nor easy to work. It is used for planking and battens, and has been suggested to be suitable for match-boxes. The

* *P. bigeminum* Mart. syn. *P. nicobaricum* Prain has been recorded only from Nicobar Islands and Ceylon and no separate economic uses are known (Kostermans, loc. cit.).

tree is one of the hosts of the lac insect and lac is grown on it in Assam (Gamble, 310 ; Rama Rao, 155 ; Roonwal *et al.*, 139).

P. globosum Kosterm. syn. *P. affine* Baker ex Benth. is a tall tree, up to 13 m. high and 30 cm. in diam., with smooth, grey bark and dark red-brown heartwood found in Assam. The fruit is reported to be used in curries and chutneys. The roots are used for poulticing boils. The timber is used in house building, though it is not durable if exposed to weather (Burkill, II, 1759 ; Kostermans, *Bull. Org. sci. Res. Indonesia*, No. 20, 1954, 36).

P. unguis-cati Benth. is a small spiny bush reported to be grown as a hedge plant in West Bengal. It stands clipping and the fruits are sometimes eaten. The bark is reported to be astringent and the seeds used for ornaments (Burkill, II, 1763 ; Hedrick, 445 ; Uphof, 285).

Pithecellobium spp. — *see* Enterolobium

PITTOSPORUM Banks ex Gaertn. (*Pittosporaceae*)

A genus of evergreen trees and shrubs distributed in the tropical and temperate regions of the Old World, being most abundant in Australia. Twelve species occur wild in India, and a few exotics have been introduced and grown in gardens.

***P. floribundum** Wight & Arn.

D.E.P., VI(1), 283 ; Fl. Br. Ind., I, 199 ; Kirt. & Basu, Pl. 89.

MAR.—*Vehkali, vikhari, vehyenti, yekaddi, pisara* ; TEL.—*Rakamuki* ; TAM.—*Kattu sampangi, nanjundai, tammata* ; KAN.—*Tammata* ; ORIYA—*Debosundu, devsan.*

KUMAUN—*Raini* ; GARHWAL—*Tumri* ; NEPAL—*Tibilti, tibiloti* ; KHASI—*Dieng-mulo-shi-ing, dieng-si-ing, dieng-duma* ; MUNDARI—*Here-kasmar.*

A small evergreen tree, up to 12 m. in height and 1.8 m. in girth, found in the hills of the peninsular India and along the foot of the outer Himalayas, from Punjab eastwards to the hills of Assam, ascending up to an altitude of *c.* 2,400 m. It is also grown in gardens and is particularly ornamental during fruiting. Bark thin, light greenish grey; leaves loosely crowded towards the ends of the branches, lanceolate to oblong-lanceolate or elliptic-oblong: flowers yellow, fragrant, in much-branched corymbose or umbelliform clusters; capsules orange-yellow, slightly compressed; seeds orange-red or blackish red, coated with a resinous, viscid fluid.

The bark is bitter and aromatic. When freshly cut, it emits a ginger-like smell. It is reported to possess expectorant, febrifuge and narcotic properties, and is used in chronic bronchitis. It is also administered in leprous affections. The tribal people grind the bark with water and apply the paste to inflammatory, dropsical and rheumatic swellings. The narcotic action of the bark is attributed to the presence of a yellow oleoresin. The bark also contains a saponin, pittosporin [Kirt. & Basu, I, 229 ; Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41**, 374 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 41 ; Cooper, *Ann. Mo. bot. Gdn*, 1956, **43**, 91].

Steam distillation of flower samples from the Himalayan plants yielded an essential oil (0.26%) having the following characteristics: $d_{4°}^{30°}$, 0.8262 ; $n_D^{30°}$, 1.6008 ; $[\alpha]_D^{30°}$, −0.10° ; acid val., 51 ; and sap. val., 227. The constituents identified in the oil are: α-pinene, dipentene, linalool, cineol, methyl salicylate, decyl aldehyde, anisaldehyde, bergapten, eugenol, indole, and salicylic and benzoic acids (Salgues, *Mat. Veg.*, 1952-54, **1**, 340).

The wood is whitish brown, lustrous, moderately hard and heavy (sp. gr., 0.68–0.74), usually straight-grained and fine- and even-textured. It is suitable for making small toys, and is also used as fuel (Indian Woods, I, 58 ; Gupta, 56).

On steam distillation the wood yields an essential oil (0.7%) having the following characteristics: $d_{4°}^{30°}$, 0.862 ; $n_D^{30°}$, 1.4840 ; $[\alpha]_D^{30}$, −2° ; acid val., 17 ; and sap. val., 29.3. The presence of octylene, *iso*-amylalcohol, terpineol, diacetyl, *iso*valeraldehyde, methyl heptenone, cineol, *n*-butyric acid, *iso*valeric acid and a sesquiterpene has been reported in the oil (Salgues, loc. cit.).

P. dasycaulon Miq. (MAR. *Gapsundi* ; KAN. *Boogri*) is a small evergreen tree with lanceolate, elliptic or broadly ovate leaves, loosely crowded towards the ends of the branches, white or yellow flowers in umbels, and globular capsules, found in the rain forests of South India ; it is probably endemic.

An extract of the stem bark shows antibacterial and antifungal activity (Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49**, 799).

* *P. floribundum* Hook. f. & Thoms. (Fl. Br. Ind.) consists of two species: *P. floribundum* Wight & Arn. and *P. napaulense* (DC.) Rehder & Wilson, the latter based on *Senacia napaulensis* DC. *P. floribundum* occurs in the peninsular India and *P. napaulense* in the Himalayas and Assam hills. These two species have, however, not so far been distinguished for medicinal and analytical purposes (Gowda, *J. Arnold Arbor.*, 1951, **32**, 330).

P. eriocarpum Royle (Hindi—*Meda tumri, garsilug, garshuma* ; Kumaun *Agni* ; Nepal—*Kakria*) is a tree endemic to the North-West Himalayas, up to an altitude of 2,100 m. *P. tetraspermum* Wight & Arn. (Mal.—*Katcha patta*), is widely distributed in the hills of South India. The woods of both these species have more or less the same properties as those of *P. floribundum* (Indian Woods, I, 58).

P. ferrugineum Ait. is a tree, up to c. 20 m. high, with elliptic leaves and yellowish white flowers in sub-umbellate clusters, found in the Nicobar Islands. The leaves and fruits act as fish poison. The fruits, though sweetish, are dangerous to eat. A tannin and an alkaloid have been reported from the leaves and fruits. The plant contains saponin.

The wood is white and fine-grained, but is not durable. It is reported to be used for rafters and as fuel (Burkill, II, 1763–64).

P. undulatum Vent., a native of Australia, is a shrub or a small tree, 5-12 m. high, with fragrant flowers. It is much grown as an ornamental hedge in gardens in the hills of South India, and has run wild at some places. In Australia, the wood is used as a substitute for box-wood (Gowda, *J. Arnold Arbor.*, 1951, **32,** 330 ; Cooper, *Ann. Mo. bot. Gdn*, 1956, **43,** 172 ; Gamble, 43).

The flowers yield an essential oil (0.26%) having an odour recalling that of jasmine. An essential oil from the fruits (0.4–0.6%) possesses a pleasant odour, and contains 75 per cent limonene. The fruits also yield a leucoanthocyanin, pentatriacontane and a saponin. The leaves and the bark are reported to contain triterpenoid saponin (Gildemeister & Hoffmann, V, 192–93 ; *Chem. Abstr.*, 1939, **33,** 5446 ; Simes *et al.*, *Bull. sci. industr. Res. Org. Aust.*, No. 281, 1959, 10).

PITYROGRAMMA Link (*Polypodiaceae*)

Fl. Malaya, II, 592.

A genus of ferns chiefly distributed in tropical America, with a few species occurring in Africa and Malagasy. *P. calomelanos* has become naturalized in India and other tropical countries.

P. calomelanos (Linn.) Link syn. *Gymnogramma calomelanos* Kaulf. is a pretty fern having conspicuous, shining black, purplish black or deep brown stipes and yellow or white, resinous, sporangial dust. It has been recorded from Purnea district of Bihar and in the vicinity of Baglung (Nepal). Sometimes it is grown for ornament. The fern enters into the preparation of a decoction with other plants for kidney troubles (Haines, VI, 1199 ; Raizada & Vaid, *Indian For.*, 1952, **78,** 576 ; Chittenden, III, 1596 ; Quisumbing, 68).

Plagioclase — *see* **Felspar**

PLANCHONELLA Pierre (*Sapotaceae*)

A genus of laticiferous trees or shrubs distributed in Seychelles, Andaman and Nicobar Islands, South-East Asia, South China, Australasia, and through Pacific to South America. Two species occur in India.

P. longipetiolata (King & Prain) H.J. Lam syn. *Pouteria longipetiolata* Baehni ; *Sideroxylon longipetiolatum* King & Prain

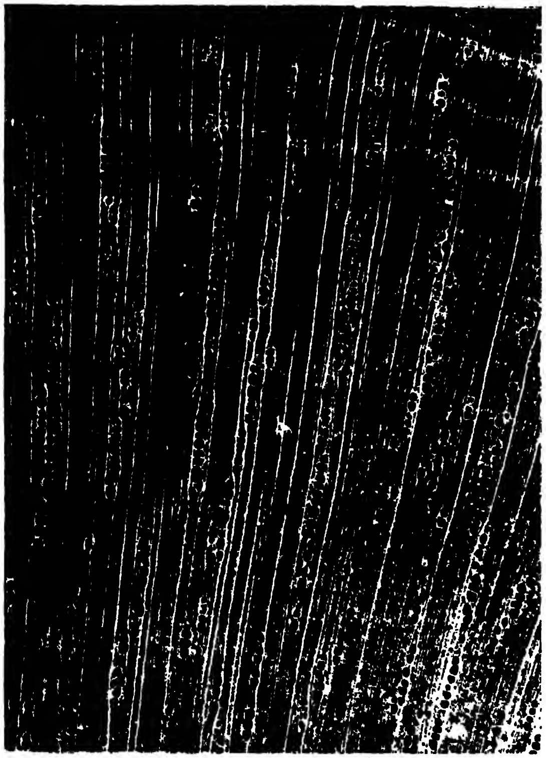
Parkinson, 197 ; King & Prain, *Ann. R. bot. Gdn, Calcutta*, 1901, **9,** 50, Pl. 63.

Trade—*Lambapatti.*

A large, often buttressed tree, up to 39 m. in height and 2.7 m. in girth, found in the Andaman and Nicobar Islands. Bark grey ; leaves in mature plants 10–20 cm. long, elliptic or obovate-lanceolate, much larger, up to 75 cm. in young plants ; flowers in axillary clusters, greenish white, small ; fruits up to 5 cm. long, ovoid or globose, succulent, dark brown when ripe ; seeds 1–2, compressed fusiform, c. 3 cm. long, dark brown, hard.

The tree is fairly common in evergreen forests and occasionally forms almost pure patches on calcareous soils. It can stand shade for a long time and on being freed from it grows straight with a long cylindrical clean bole. Flowering is irregular with no annual production of good seeds ; seedlings, however, stand transplanting well. Though the viability of seeds is very low (c. 3 per cent), natural regeneration comes up plentifully during the course of regenerating the forests. Direct sowing and planting have also been successful. If large quantities of seeds are available, broadcasting or dibbling them under shade in regeneration areas is preferable. Introduction of lambapatti in suitable localities in Assam, Bengal, and western ghats has been recommended (*Indian For.*, 1952, **78,** 274 ; Ganapathy & Rangarajan, ibid., 1964, **90,** 758).

The wood is white, soft and light (wt., 545 kg./cu.m.). It is non-refractory, very liable to stain, mould and rot, but can withstand rapid drying. Air seasoning should be carried out under a good weather-proof roof with the timber piled in such a way that all sides are exposed to air. The wood is not durable ; average life is less than 5 years. Heartwood is easily treatable. The fallen timber is affected by borers [Parkinson, 197 ; Trotter, 1944, 15–16 ; IS:



F.R.I., Dehra Dun. Photo : Ramesh Rao

FIG. 48—PLANCHONELLA LONGIPETIOLATA—TRANSVERSE SECTION OF WOOD (×10)

399–1952, 15, 17 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(8), 1960, 55].

Lambapatti wood is used in match industry both for boxes and splints. It is one of the finest matchwoods and comes up to the standard of European Aspen (*Populus tremula* Linn.) for splints. It is suitable also for light packing cases, plywood, turnery and toys. The leaves are used as fodder for elephants. Andamanese are reported to bake fish and pork in the large leaves of young plants (Trotter, 1944, 213 ; *Indian For.*, 1952, **78**, 274 ; IS: 399–1952, 17 ; Parkinson, 197).

P. obovata (R. Br.) Pierre syn. *Pouteria obovata* Baehni : *Sideroxylon ferrugineum* Hook. & Arn.

Fl. Br. Ind., III, 537 ; Van Royen, *Blumea*, 1955–57, **8**, 368.

A medium-sized to large buttressed tree, sometimes up to 40 m. in height, found in the Andaman and Nicobar Islands. Bark brownish grey, fissured ; leaves 6–24 cm. long, very variable, obovate to lanceolate or linear ; flowers in clusters, greenish white, small ; fruit *c.* 1.5 cm. long, obovoid or globose, 1–5 seeded.

The wood is pinkish, very pretty, hard and heavy and is suitable for cabinet-work, carving and turnery. In Malaya, a decoction of the leaves is drunk for pain in the stomach and chest ; a poultice of the crushed leaves is applied on the loins in lumbago. The bark after heating is chewed for sprue. The leaves are reported to contain saponin and the bark and leaves an alkaloid (Burkill, II, 1766).

The seeds yield 41 per cent of a non-drying fatty oil with the following characteristics: $d_{4°}^{30°}$, 0.9082 ; $n_{D}^{30°}$, 1.4650 ; acid val., 20.4 ; sap. val., 189.1 ; iod. val., 77.6 ; and unsapon. matter, 0.37%. The oil contains 23.6 per cent solid acids (mostly palmitic and some myristic) and 76.4 per cent liquid acids comprising 77 per cent oleic and 23 per cent linoleic (Eckey, 713 ; *Chem. Abstr.*, 1936, **30**, 314).

PLANCHONIA Blume (*Lecythidaceae*)

A small genus of trees distributed in Indo-Malaysian region and Australia. One species occurs in the Andaman Islands.

***P. valida** Blume syn. *P. littoralis* Van Houtte ; *P. andamanica* King

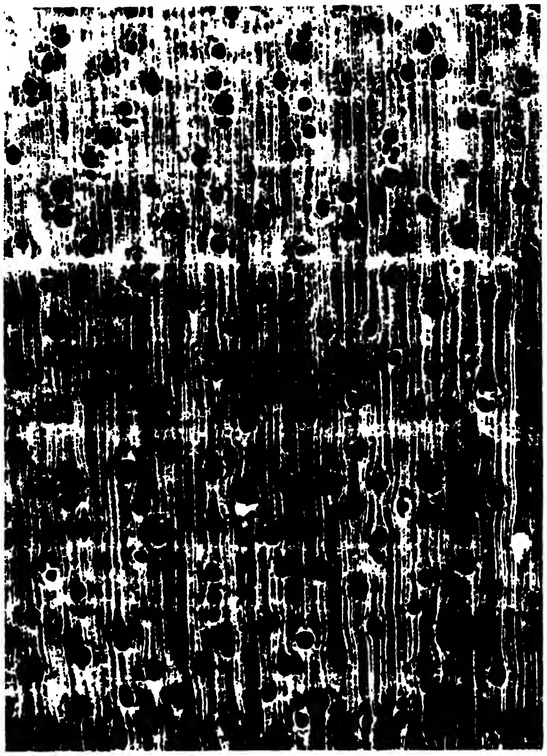
D.E.P., VI(1), 284 ; Fl. Br. Ind., II, 511 ; Kartawinata, *Bull. bot. Surv. India*, 1965, **7**, 162, Fig. 1 & 4.

ANDAMANS—*Lal bombway, baila da.*

A tall tree, sometimes up to 36 m. in height and 3 m. in girth, found in the coastal forests of the Andaman Islands. Bark dark brown ; leaves obovate to broadly elliptic, 10–20 cm. × 5.0–12.5 cm. ; flowers in short terminal racemes, pinkish white ; fruit a berry.

The wood is reddish brown with yellow specks, moderately interlocked-grained, medium coarse-textured, hard, strong and heavy (av. wt., 865 kg./cu.m.). It is a refractory timber and should be seasoned in well-ventilated sheds. It is only moderately durable ; graveyard tests indicated a durability up to two years. The wood can be easily treated. It works and finishes well and takes a fine polish. The data for the comparative suitability of the timber, expressed as percentage of the same properties of teak, are: wt., 135 ; strength as a beam, 100 ; stiffness as a beam, 115 ; suitability as a post, 105 ; shock-resisting ability, 105 ; retention of shape, 50 ; shear, 110 ; and hardness, 145. The wood is used in the Andamans for house construction for beams, columns, planks, doors and

* Some authors consider the Andaman species, *P. andamanica* King, distinct from the Malayan and Indonesian species, *P. valida* Blume (Burkill, II, 1766 ; Kartawinata, *Bull. bot. Surv. India*, 1965, **7**, 162).



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 49—PLANCHONIA VALIDA—TRANSVERSE SECTION OF WOOD (×10)

windows. In Malaya and Indonesia, it is used also for furniture, cabinet-work, flooring, ship-framing, bent-wood work, etc. The wood is suitable for commercial and tea-chest plywood and tool handles. In Java, the young leaves are reported to be eaten with rice (Gamble, 365; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 57, Sheet No. 16; Trotter, 1944, 12; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; ibid., 1952, **78**, 276, 278; Sekhar & Bhartari, ibid., 1964, **90**, 767; Kartawinata, *Bull. bot. Surv. India*, 1965, **7**, 162; Uphof, 285).

The leaves, shoots and fallen wood are affected by a number of insect pests [Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 42].

Plane, Oriental — *see* **Platanus**

PLANTAGO Linn. (*Plantaginaceae*)

A large genus of herbs or sub-shrubs distributed mostly in the temperate regions, and a few in the tropics. About ten species are recorded in India, of which *P. ovata* is important for its seeds (*Isubgol*) used in medicine.

P. amplexicaulis Cav.

D.E.P., VI(1), 284; Fl. Br. Ind., IV, 706; Kirt. & Basu, Pl. 781C.

PUNJAB—*Isafghol.*

A stemless or sub-caulescent herb widely distributed in the countries of the Mediterranean region, recorded occasionally from Rajasthan and Delhi. Leaves radical, narrowly lanceolate, entire or very sparingly toothed; flowers white, in ovoid spikes; capsules ovoid, sub-obtuse, pale brown, smooth, 2-seeded; seeds oblong, boat-shaped, brown or nearly black.

The Indian plant is considered to be a variety var. *bauphula* (Edgew.) Pilger. *P. amplexicaulis* is said to be the source of brown *isubgol* seeds met with in Indian bazaars. The seeds are larger than those obtained from *P. ovata* (q.v.) and probably possess equally good demulcent properties. The mucilaginous matter is contained mainly in the seed coat along with some tannin. The endosperm contains protein and a fatty oil. Seeds are considered astringent, and used in intermittent fever, pulmonary affections, and as an application to the eyes in ophthalmia. In Baluchistan, juice of the seeds is taken in hot weather as a cooling drink (Pilger in Das Pflanzenreich, Heft 102, 1937, 310–11; Chopra, 1958, 379; *Chem. Abstr.*, 1959, **53**, 20695; Kirt. & Basu, III, 2039; Burkill, 1909, 62).

P. asiatica Linn. syn. *P. major* Hook. f. non Linn.

D.E.P., VI(1), 285; Fl. Br. Ind., IV, 705 in part.

KAN.—*Sirapotta gida.*

A perennial herb with stout rootstock found in Simla, Kumaun, Sikkim, Lushai hills, and hills of South India. Leaves radical, ovate, entire, coarsely dentate or lobed; flowers scattered or crowded, in spikes; capsules egg-shaped; seeds small, black.

P. asiatica is said to have properties similar to those of *P. major* Linn. (q.v.). The leaves contain the glucosides plantaginin (scutellarein-7-glucoside) and aucubin ($C_{15}H_{22}O_9$, m.p. 181°), besides succinic and plantenolic acids, choline and adenine. On extraction with hot methyl alcohol, the dried whole herb gave ursolic acid, β-sitosteryl palmitate, β-stigmasteryl palmitate, β-sitosterol, and *n*-hentriacontane. The seeds are used in haematuria, and inflammatory conditions of the mucous membrane of gastro-intestinal and genito-urinary tracts. The seeds contain aucubin and 8.1% fatty oil (Hoppe, 711; *Chem. Abstr.*, 1962, **56**, 14395; 1937, **31**, 7599; 1957, **51**, 18651; 1965, **62**, 13518; *Bull. bot. Surv. India*, 1960, **2**, 244;

Dictionary of Organic Compounds, I, 292 ; Wehmer, II, 1145).

P. lanceolata Linn.

D.E.P., VI(1), 284 ; Fl. Br. Ind., IV, 706 ; Kirt. & Basu, Pl. 781A.

Hindi—*Baltanga.*

A perennial herb found in the western Himalayas from Kashmir to Simla at altitudes of 1,500–2,400 m. Leaves lanceolate, entire or toothed, 20–30 cm. long and 2–4 cm. broad ; spikes ovoid, sub-globose or cylindric ; seeds oblong, concavo-convex, black.

P. lanceolata is a variable species mostly Eurasian, but found also introduced in North America. The Indian plant is referred to var. *mediterranea* (Kerner) Pilger. It is sometimes cultivated for its medicinally valuable leaves. Under cultivation in Europe, the plant yields 2–3 cuttings in first year and 4–5 in second year (Pilger in Das Pflanzenreich, Heft 102, 1937, 313–27 ; Freudenberg & Caesar, 117 ; Auster & Schaefer, Leiferung, 19, No. 52, 1958).

The leaves and roots of the plant are considered astringent, vulnerary and alterative and are used for coughs, pulmonary diseases and asthma. The leaves are used as an application to wounds, inflamed surfaces and sores. The glucoside aucubin is present in the leaves and roots. The leaves also contain tannin (2.1%), carotene (0.56 mg./100 g.), and thiocyanogen (20 mg./100 g. of leaf juice). The alkaloid content of the twigs and leaves is reported to be 0.26 per cent. The leaves and their aqueous extracts promote epithelial growth, diminish hyperemia and accelerate promotion of scab ; they also promote clotting of blood in rabbit. Alcoholic extracts of young leaves exhibit antibacterial action against *Streptococcus betahaemolyticus, Micrococcus pyogenes* var. *aureus* and *Bacillus subtilis,* thus confirming their wound-healing properties. The powdered plant mixed with normal diet is said to cause temporary sterility (Jacobs & Burlage, 162 ; Hocking, 176 ; Wehmer, II, 1146 ; Wiesner, I, 279 ; Deuel, I, 518 ; Hoppe, 711 ; Ikram & Islam, *Pakist. J. sci. industr. Res.*, 1963, **6**, 53 ; Kirt. & Basu, III, 2038 ; *Chem. Abstr.*, 1953, **47**, 12652 ; *Biol. Abstr.*, 1959, **33**, 1890 ; Laszlo & Henshaw, *Science*, 1954, **119**, 629).

P. lanceolata is occasionally used as a stock feed in the absence of better fodder. It contains 8.5 per cent of protein and is a good source of calcium (CaO, 1.56%) and phosphorus (P_2O_5, 0.88%). The young leaves are eaten as a vegetable and are recommended as food in times of scarcity (Armstrong, *J. Sci. Fd Agric.*, 1951, **2**, 168 ; Watt & Breyer-Brandwijk, 848 ; Uphof, 285 ; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 65 ; Dougall, *E. Afr. agric. J.*, 1953–54, **19**, 152).

The seeds are used as bird feed. They are considered diuretic, purgative and haemostatic. They contain 6.5 per cent of mucilage and are used as an adulterant of Black Psyllium from France or Spain. The mucilage yields on hydrolysis *d*-xylose (72%), *d*-galacturonic acid (15%), *l*-rhamnose (11%), and *d*-galactose. Aucubin (1.1%), tannin and a fatty oil (8–9%) have been reported in the seeds (Hoppe, 711 ; Smith & Montgomery, 23, 110 ; Kirt. & Basu, III, 2038 ; Nadkarni, I, 986 ; Bailey, 1947, III, 2656 ; *Chem. Abstr.*, 1953, **47**, 1243 ; Mensier, 462).

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FIG. 50—PLANTAGO LANCEOLATA—FLOWERING PLANT

P. major Linn.

D.E.P., VI(1), 285 ; Fl. Br. Ind., IV, 705 in part ; Kirt. & Basu, Pl. 780.

Kashmir—*Gul, isafghol ;* Punjab—*Ghuzbe, gul, isafgol, karet ;* Kumaun—*Luhuriya.*

A perennial herb with erect, stout rootstock found in the temperate and alpine Himalayas from Kashmir to Bhutan at altitudes of 600–3,500 m., in Aka hills and hills of N.E.F.A. Leaves radical, ovate or ovate-

oblong, entire or toothed, 8–20 cm. long and 4–7 cm. broad; flowers small, green, crowded or scattered in long slender rather lax spikes; capsules ovoid; seeds 4–8, minute, oval, dull black, rugulose.

The plant is grown as a pot-herb in parts of southern U.S.A. The leaves are eaten by Chinese. They are saline, bitterish and acrid to taste. Analysis of the fresh leaves gave the following values: moisture, 81.4; crude protein, 2.7; N-free extr., 11.2; fat, 0.4; crude fibre, 2.1; and ash, 2.2%. The leaves are reported to contain aucubin (1%), mucilage, tannin (c. 4%), saponins, volatile oil, potassium salts (0.46%), citric acid and vitamins A, C, and K [Ockert, *Acta phytother., Amst.*, 1955, **2**(10), 19; Burkill, II, 1768; Wehmer, II, 1145; U.S.D., 1947, 1554; Hoppe, 711; *Chem. Abstr.*, 1953, **47,** 1243; 1947, **41,** 2210].

The plant is considered haemostatic and wound-healing in burns and inflammation of tissues. In homoeopathy, it is used in disorders of the epidermis, and in headache, earache and toothache. The leaves are considered cooling, alterative, febrifuge, diuretic, astringent and vulnerary. An infusion of the leaves is useful in diarrhoea and piles. In Tuscany, a decoction of leaves is reputed as an excellent eye wash, and an ointment prepared from them is applied to sore eyes. A 10 per cent ointment of powdered leaves in peach seed oil or vaseline is used for suppurative skin diseases as an anti-pruritic and in impetigo and ecthyma. The application is anti-inflammatory and aids in epithelialization without any injurious side reactions (Hoppe, 711; Wren, 240; Kirt. & Basu, III, 2035–36; Watt & Breyer-Brandwijk, 849; Jacobs & Burlage, 162; *Chem. Abstr.*, 1947, **41,** 2210; Aliev, *Amer. J. Pharm.*, 1950, **122,** 24).

The roots are saline and sweetish to taste. They are considered astringent and febrifuge, and their decoction is used for coughs (U.S.D., 1947, 1554; Kirt. & Basu, III, 2035; Burkill, II, 1768).

The seeds are considered demulcent, stimulant, diuretic and tonic, and are used as a remedy for dysentery and diarrhoea. The seeds of *P. major*, like those of other *Plantago* species, contain mucilaginous matter mainly in the seed coat along with some tannin. They are used as an adulterant for *isubgol*. They contain: crude protein, 18.8; crude fibre, 19; fatty oil, 9.8 (up to 22%); and ash, 5%. The presence of plantagic acid has been reported. The seed oil (sp. gr.$^{15°}$, 0.932; sap. val., 183; and iod. val., 138.5) is yellow in colour with an agreeable odour, and a taste resembling that of walnut. It is suitable for edible purposes. The seeds are used as a bird feed and are fed after crushing and boiling (*Chem. Abstr.*, 1959, **53,** 20695; Wehmer, II, 1145; Hoppe, 711; Mensier, 462; Kirt. & Basu, III, 2035; I.P.C., 125; Williams & Williams, 260; Burkill, II, 1768).

The leaves and roots when chewed impart a red tinge to the saliva. The leaves colour aluminium-mordanted cotton dull yellow. Aucubin is present in roots and inflorescences. The presence of alkaloids (0.1%) has also been reported in the plant. The plant is a persistent lawn and vine yard pest in some countries and application of 2, 4-D (1.2 kg./ha.) or amitol (7.5 kg./ha.) has been tried for control [Perkin & Everest, 636; Ikram & Islam, *Pakist. J. sci. industr. Res.*, 1963, **6**, 53; Ram Gopal, *Indian Fmg, N.S.*, 1954 55, **4**(10), 23; *Chem. Abstr.*, 1963, **59,** 4487].

P. ovata Forsk. BLOND PSYLLIUM, ISPAGHULA, SPOGEL SEEDS

D.E.P., VI(1), 285; Fl. Br. Ind., IV, 707; Kirt. & Basu, Pl. 782A.

PERS. -*Isabghul*; HINDI—*Isubgol*; BENG.—*Eshopgol*; MAR. *Isabgola*; GUJ.—*Isapghol, ghoda jeeru, umto jeeru*; TEL.—*Isapgola vitulu*; TAM.—*Iskolvirai*; KAN.—*Isafgolu, visamagolu*; MAL.—*Karkatasringi*.

A stemless or sub-caulescent softly hairy or woolly annual herb: leaves narrowly linear or filiform, entire or distantly toothed; flowers in cylindric or ovoid spikes; capsules ellipsoid, 8 mm. long, obtuse, the upper half coming off as a blunt conical lid, membranous, glabrous; seeds ovoid-oblong, 3 mm. long, boat-shaped, smooth, yellowish brown.

P. ovata is indigenous to the Mediterranean region and West Asia, extending up to Sutlej and Sind in West Pakistan. It has been introduced into India and cultivated for its seeds which are mainly valued for their husk. Its cultivation on a commercial scale is confined to the districts of Banaskantha and Mehsana in North Gujarat. It is also grown to a very small extent in Patiala and Hissar districts of Punjab and in Uttar Pradesh. Outside India, it is cultivated on a limited scale in some areas of West Pakistan [Sampson, *Kew Bull., Addl Ser.*, XII, 1936, 144; *Brochure on the Marketing of Isubgol in India, Brochure Ser.*, No. 4, 1949, 1–3; Jagjit Singh, *Indian For.*, 1962, **88,** 907; 1964, **90,** 500; Khan, *Punjab Fr. J.*, 1957, **21**(76), 31].

Attempts have been made to cultivate it in U.S.A., and a project was started to obtain improved types by selection, hybridization and induction of polyploidy. While tetraploids showed greater vigour, larger seed size and greater quantity of mucilage,

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FIG. 51—PLANTAGO OVATA—FLOWERING PLANT

they were less fertile than diploids (Chandler, *Contr. Boyce Thompson Inst.*, 1954, **17**, 495).

Cultivation— *P. ovata* is a hardy crop and can be grown on a variety of soils, but it does well on rich, well-drained loamy soil. It is recommended as a suitable crop where soils are sandy or *goradu* in Gujarat. Cool and dry weather is favourable to the crop. Rainy and cloudy weather at the time of maturity and frost at the flowering stage affect adversely both yield and quality of the seeds [*Brochure Marketing Isubgol*, 1949, 2 ; Vachhani, *Indian Fmg*, 1943, **4**, 417 ; Joshi & Tahiliani, *Farmer*, 1956, **7**(10), 77].

The land should be given a thorough preparatory tillage of 4–6 ploughings and brought to a fine tilth. No manure is usually given, but if need be, 30–35 cartloads of well-rotten farmyard manure should be applied to a hectare of land. The land after being levelled and pressed with a plank is laid out into small compartments to facilitate irrigation. Sowing is done by the end of October continuing up to the middle of December. Seed is sown broadcast or drilled in lines 30 cm. apart. The seed rate varies from 6 kg. to 13 kg. per hectare. Seeds are gently mixed in the soil with a broom made of weeds. Recent experiments show that better yield can be had by sowing seeds by the middle of October in rows 22.5 cm. apart with a seed rate of 7 kg. per hectare [Joshi & Tahiliani, loc. cit. ; Vachhani, loc. cit. ; Khan, loc. cit. ; *Brochure Marketing Isubgol*, 1949, 2 ; Singh *et al.*, *Agric. Anim. Husb., Uttar Pradesh*, 1955–56, **6**(6), 29].

The crop is given 5–8 irrigations till it attains maturity. First irrigation is done immediately after sowing. If the seed fails to germinate within four days of sowing, then a second light watering is given. Generally first irrigation is done 20–30 days after sowing, and subsequent irrigations at an interval of 7–10 days. Weeding is done when the crop is about 1½ months old. The plant gives out profuse tillerings and the tillers vary from 25 to 80 in number depending on the fertility of the soil. If the crop is drilled, one or two hoeings are needed. Earhead formation starts after 1½ months and flowering starts after two months of sowing (Joshi & Tahiliani, loc. cit. ; Khan, loc. cit.).

The crop is ready for harvesting in about 3½–4 months from sowing. The spikes are harvested in March–April when they turn red. Harvesting is done in the early morning when a little dew is present which prevents seed shedding. Plants are cut 15 cm. above the ground with a sickle ; they are then brought to the threshing yard where threshing is done. The threshed material is winnowed, sieved and repeatedly winnowed till the seed is clean. The yield of seed varies from 500 to 1,100 kg. per hectare (Joshi & Tahiliani, loc. cit. ; Vachhani, loc. cit. ; Khan, loc. cit.).

Processing—The seeds of *P. ovata* are mainly valued for their mucilaginous husk, a thin white membrane, covering the concave side of the seeds. In India, husk is often sold separately. The husk is separated from the seeds by crushing and winnowing. Crushing is done with emery grinders or flat-stone grinding mills which may be hand- or power-driven. The seeds after thorough cleaning are passed through these mills six to seven times for complete removal of the husk. The crushed material consisting of husk and kernel is sieved to remove kernels, after which it is passed through screens of 30, 40, 60, 70, 80 and 100 mesh to separate it out into products of different fineness, such as Ordinary shell (also called Broken shell), Flat husk and Powdered husk. The husks obtained (total yield, 26–27%) from the different millings vary in quality and are kept separate and mixed in different proportions according to the quality in demand. Most of the factories engaged in

the processing of *isubgol* husk are concentrated in Banaskantha and Mehsana districts of Gujarat. The important centres are Sidhpur, Unjha, Patan and Palanpur (*Brochure Marketing Isubgol*, 1949, 5; I.P.C., 126; Joshi & Tahiliani, loc. cit.; Information from Messrs Sidhpur Sat-Isabgol Factory, Gujarat).

Composition and Utilization—Isubgol (Ispaghula, Spogel Seeds, Isafgul) consists of the dried seeds of *P. ovata* and is used medicinally. Seeds contain over 30 per cent of mucilage. The husk of the seeds contains all the mucilaginous matter and is sometimes prescribed instead of the whole seeds. Both the dried seeds and husks are official in Indian Pharmacopoeia. Seeds are hard, translucent, smooth, mucilaginous; concave surface of the seeds contains the hilum covered with a thin membrane. The I.P. specifications for the seeds are: wt. of 100 seeds, $\not<$0.17 g. and $\not>$0.22 g.; foreign organic matter, $\not>$2.0%; ash, $\not>$3.0%; acid insoluble ash, $\not>$0.6%; swelling factor: 1 g. of seeds agitated gently and occasionally during 24 hours in a 25 ml. stoppered cylinder filled to the 20 ml. mark with water, and allowed to stand for 1 hour occupies a volume, $\not<$10 ml. (Mantell, 132; I.P.C., 124; B.P.C., 1963, 410; Chopra, 1958, 379; I.P., 353).

The husk (Ispaghula Husk, Ispaghulae Testa; Hindi—*Isubgol-ki-bhusi*; Beng.—*Isabguler bhusi*; Guj.—*Kalai*) is thin, boat-shaped (2–3 mm. × 0.5–1.0 mm.), white, translucent, odourless, with a bland mucilaginous taste. According to I.P. it should contain: foreign organic matter, $\not>$2%; ash, $\not>$2.9%; acid insoluble ash, $\not>$0.45%; swelling factor: 1 g. of husk agitated gently and occasionally for 4 hours in a 25 ml. stoppered cylinder filled to the 20 ml. mark with water, and allowed to stand for 1 hour should occupy 20 ml. and set to a jelly. Recent investigation on ispaghula husk suggests that for testing the purity of the drug the standards specified in I.P. need upward revision; the proposed values are as follows: foreign organic matter, $\not>$2%; ash, $\not>$2%; acid insoluble ash, $\not>$0.2%; swelling factor, 55; and non-mobile gel vol., $\not<$40 ml. The seeds and husk are stored in dry well-closed containers (I.P., 354; Atal & Kapur, *Indian J. Pharm.*, 1963, **25**, 376; I.P.C., 126).

The dried seeds and husk are used as emollient, demulcent and laxative, and in the treatment of chronic constipation, amoebic and bacillary dysentery and diarrhoea due to irritative conditions of gastro-intestinal tract. *Isubgol* preparations are given after colostomy to assist the production of a smooth solid faecal mass. In indigenous medicine the seeds are considered cooling and diuretic as well, and recommended in febrile conditions and the affections of kidneys, bladder and urethra. A decoction of seeds is prescribed in cough and cold, and the crushed seeds

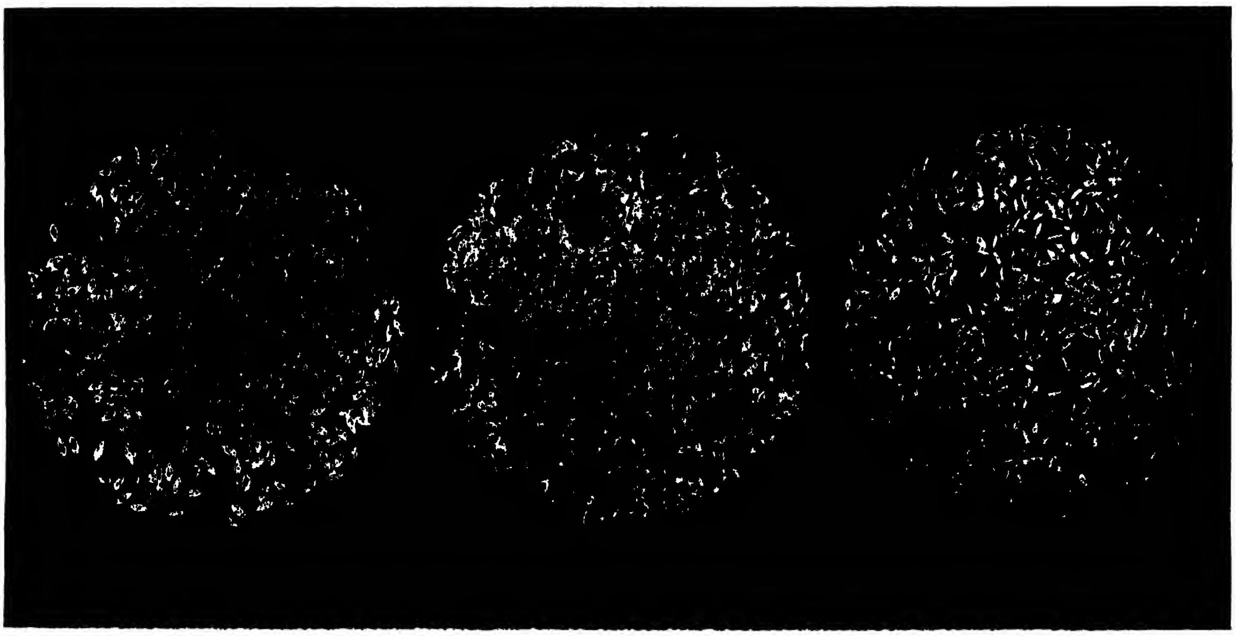

FIG. 52—PLANTAGO OVATA (ISABGOL): (1) UNHUSKED SEEDS; (2) HUSK; (3) DEHUSKED SEEDS

made into a poultice are applied to rheumatic and glandular swellings (I.P., 353–54; Chopra, 1958, 380, 382; I.P.C., 125; U.S.D., 1955, 1070).

The efficacy of *isubgol* is due entirely to the large quantity of mucilage present in the husk. The action of *isubgol* is purely mechanical, the effective constituent being the seed husk which swells into a jelly-like mass with cold water. *Isubgol* mucilage relieves constipation by mechanically stimulating the intestinal peristalsis. The mucilage has been found to be practically unaffected by the digestive enzymes and bacteria and passes unchanged through the intestines; during its passage the mucilage lines the mucous membrane, and exercises a soothing and protective action as a demulcent, emollient and lubricant. The toxins present in the gut are absorbed by the gel of the mucilage and thus are prevented from absorption into the system. The seeds (dose 5–15 g.) are soaked in water for several hours before being taken since as such they may cause irritation in inflammatory condition of the alimentary tract, and may lead to spasm and an increase in constipation. As the retention of seeds in the intestine may also form a nucleus for mechanical obstruction, the seed husk (dose 0.5–2.0 g.) is preferred to whole seeds especially in acute conditions. The mucilage acts in very much the same way as liquid paraffin, but is considerably cheaper and is free from the injurious effects produced by the habitual use of paraffin, viz. malignant disease of colon, eczema ani, paraffin pains, etc. (I.P.C., 125–26; Chopra, 1958, 381–85).

The mucilage of *isubgol* is colloidal in nature and its composition varies with the conditions of preparation. It is mainly composed of xylose, arabinose and galacturonic acid; rhamnose and galactose have also been reported. Two polysaccharide fractions have been separated from the mucilage. One fraction (eq. wt., 700; uronic acid, 20%) is soluble in cold water and on hydrolysis yields *d*-xylose (46%), an aldobiouronic acid (40%), *l*-arabinose (7%), and insol. residue (2%); the other fraction (eq. wt., 4,000; uronic acid, 3%) is soluble in hot water forming a highly viscous solution which sets to a gel on cooling and yields on hydrolysis *d*-xylose (80%), *l*-arabinose (14%), aldobiouronic acid (0.3%), and trace of *d*-galactose (Whistler & BeMiller, 445–46; Smith & Montgomery, 360–64).

The seeds contain in addition to mucilage, a semi-drying fatty oil (5%), small amounts of aucubin, and tannin, and an active principle exhibiting acetylcholine-like action. The fatty oil solidifies at $-8°$, and has a bright yellow colour and the following characteristics: sp. gr.$^{22°}$, 0.9212; $n_D^{28°}$, 1.4737; $[\alpha]_D^{20°}$, $-0.1°$; acid val., 5–166; sap. val., 181.8; iod. val., 116.0; acet. val., 37.7; Hehner val., 91.8; and unsapon. matter (containing sitosterol), 1.8–2.0%. The constituent fatty acids in the oil are: linolenic, 0.2; linoleic, 47.9; oleic, 36.7; palmitic, 3.7; stearic, 6.9; and lignoceric, 0.8%. The embryo yields 14.7 per cent of a linoleic acid-rich oil (iod. val., 120.2; linoleic acid, 53.4%) whose use has been suggested as a dietary hypocholesterolemic agent in place of corn oil. Feeding of the embryo oil as dietary supplement for lowering the serum cholesterol level gave encouraging results in experimental animals (I.P.C., 125; Chopra, 1958, 380; Sanghavi, *Bombay Technol.*, 1962, **12**, 131; Pendse & Dutt, *Proc. Acad. Sci., United Provinces*, 1934, **4**, 133; Pendse, *Proc. nat. Acad. Sci. India*, 1937, **7**, 137; Atal *et al.*, *Indian J. Pharm.*, 1964, **26**, 163).

Extracts useful in food and pharmaceutical industries can be prepared from *isubgol*. The seed mucilage is used in cosmetics and as a basic stabilizer in ice-cream industry. It is also useful for sizing purposes and for the preparation of chocolates. Made into a paste, the husk forms an excellent thickener either alone or in mixture with wheat starch paste. A jelly useful as a substitute for agar-agar can be obtained by treating the husk with hot caustic soda solution and subsequent neutralization. The husk has been found to act as a good binder and disintegrant in compressed tablets. The deep red, hard, husked seed kernels (Guj.—*Gola, goli*), mixed with guar are used as cattle feed [Bhunvara & Khorana, *Indian J. Pharm.*, 1950, **12**, 68; Aggarwal, Indian Pat., No. 50048, 1955; *Brochure Marketing Isubgol*, 1949, 6–8; Joshi & Tahiliani, loc. cit.; Ramachandran & Venkataraman, *J. Soc. Dy. Col.*, 1938, **54**, 462; Patel & Alex, *Pharmaceutist*, 1966, **12**(6), 13; Mithal & Bhutiani, *Indian J. Pharm.*, 1967, **29**, 329; Williams, *Agric. Handb. U.S. Dep. Agric.*, No. 172, 1960, 25].

Alcoholic extracts of the seeds exhibit cholinergic properties. They lower the blood pressure in anaesthetized cats and dogs, inhibit the isolated and perfused hearts of rabbits and frogs, and stimulate the movements of intestines of rabbits, rats and guinea-pigs. The activity of the extract on smooth muscle is inhibited by atropine (Khorana *et al.*, *Indian J. Pharm.*, 1958, **20**, 3).

Substitutes and Adulterants—The seeds are frequently mixed with seeds of *Salvia aegyptiaca* Linn. which also yield copious mucilage. Commer-

cial sample of *isubgol* may consist of the seeds of *P. arenaria* Waldst., *P. lanceolata* and *P. major*, besides *P. ovata* and *P. psyllium*. They can be identified by their external colour, shape and outline (I.P.C., 125).

Production and Trade—Complete data relating to the area under cultivation of *isubgol* and the production of seeds and husk in India are not available. As *isubgol* is mostly grown in Mehsana district of Gujarat, its area under cultivation and production of husk in this district is given in Table 1. India is the main supplier of *isubgol* seeds and husk to the world market. More than 800,000 kg. of *isubgol* seeds and more than 3 million kg. of husk are estimated to be exported annually. U.S.A. is the chief importer of *isubgol* seeds and husk. The quantity of seeds and husk exported from India is given in Tables 2 and 3, respectively. For export, husk is packed under three

TABLE 1—AREA UNDER CULTIVATION OF P. OVATA AND PRODUCTION OF HUSK IN MEHSANA DISTRICT (GUJARAT)*

	Area (hectares)	Production of husk (tonnes)
1958-59	4,387	4,659
1959-60	4,433	4,697
1960-61	5,186	6,461
1961-62	5,067	4,766
1962-63	5,334	3,453
1963-64	n.a.	n.a.
1964-65	6,360	3,605
1965-66	11,146	8,436
1966-67	6,929	2,445

* Information from Director of Agriculture, Gujarat.
n.a.—not available.

TABLE 2—EXPORTS OF ISUBGOL SEEDS
(Qty in kg.)

	U.S.A.	Germany	U.K.	Pakistan	France	Belgium	Others	Total Qty (kg.)	Total Val. (Rs.)
1957	129,037	7,061	13,310	8,078	7,112	12,701	12,446	189,745	390,032
1958	62,994	8,992	11,329	112,780	8,433	4,979	9,754	219,261	211,755
1959	164,344	53,190	13,158	81,690	..	4,521	7,366	324,269	588,804
1960-61	131,661	57,723	10,222	36,203	8,235	4,098	20,843	268,985	445,680
1961-62	72,157	135,452	16,841	35,435	8,128	10,632	39,369	318,014	342,341
1962-63	61,964	87,241	4,202	20,139	2,033	3,809	7,763	187,151	276,141
1963-64	128,185	166,117	8,970	447	6,194	7,359	4,664	321,936	859,564
1964-65	90,415	75,175	29,700	8,183	15,507	8,128	10,506	237,614	620,700
1965-66	63,419	249,162	1,291	..	6,096	5,740	3,506	329,214	571,319
1966-67	201,107	246,876	14,797	..	7,644	6,895	406,734	884,053	1,782,641

TABLE 3—EXPORTS OF ISUBGOL HUSK
(Qty in kg.)

	U.S.A.	U.K.	Pakistan	France	Others	Total Qty (kg.)	Total Val. (Rs.)
1957	1,180,537	112,831	92,510	41,150	6,604	1,433,632	4,755,401
1958	1,177,438	35,561	132,746	20,575	16,867	1,383,187	3,783,290
1959	1,281,328	78,641	117,657	17,984	12,192	1,507,802	4,425,638
1960-61	535,845	93,904	127,547	35,868	14,184	807,348	3,070,221
1961-62	1,523,711	95,641	94,963	67,985	18,348	1,800,648	6,044,245
1962-63	975,224	47,106	129,448	112,956	19,270	1,284,004	5,736,904
1963-64	1,385,233	63,140	99,997	158,664	19,321	1,626,355	8,696,093
1964-65	1,808,508	95,173	107,425	192,901	25,049	2,229,056	13,035,915
1965-66	2,340,469	100,363	33,470	171,564	27,725	2,673,591	16,974,205
1966-67	3,254,989	66,851	..	195,770	62,779	3,580,389	22,541,597

qualities, viz. 50, 60 and 70 mesh clean; at present most of the exports consist of 70 mesh clean. In the pre-war period, France was the only serious competitor for India in the *isubgol* trade. The French product consists of seeds and husk of *P. psyllium,* the quality of which is, however, reported to be inferior to that of the Indian produce obtained from *P. ovata* (*Brochure Marketing Isubgol,* 1949, 6, 9).

Isubgol husk, commonly known in commerce as *Bhusi* or *Sat isubgol,* is available in the market in various grades. There are no well-defined or commonly accepted standards of quality in vogue and each manufacturer prepares his own grades by mixing varying proportions of husk obtained from different millings. The quality of husk is determined by its size, colour, presence of red scrapings of the upper layer of the kernel, husk powder and dust. Husk of large size, white in colour and free from red scrapings, is the best. Husk of superior quality is packed in cardboard containers of 0.45, 0.23 and 0.11 kg. capacities; it is sometimes adulterated with powdered parched rice (*Brochure Marketing Isubgol,* 1949, 6).

P. psyllium Linn. BLACK PSYLLIUM

Fl. Br. Ind., IV, 707; Chohan & Shah, *J. Bombay nat. Hist. Soc.,* 1965, **62,** 327, Fig. 1–4.

HINDI—*Kala isabgol.*

An erect, much-branched annual herb, 30–45 cm. tall, native of the Mediterranean region (especially the south of France), and found growing in cultivated fields in Gujarat. Leaves opposite or sub-opposite, apparently whorled, narrowly linear; flowers rosy pink, in ovoid spikes; fruits glabrous; seeds boat-shaped, yellowish brown, glabrous.

P. psyllium is fairly drought-resistant, and does well on a rich well-drained loamy soil. Seed is sown in September–October by broadcast or in lines 30 cm. apart at the rate of 2–5 kg. per hectare. It does not require much care except one or two hoeings. It flowers in May and is usually harvested in the middle of June. An average yield of 300–400 kg. of seeds per hectare has been obtained (Luthra & Suri, *Spec. Bull. Dep. Agric. Punjab,* 1936, 15).

The seeds of *P. psyllium* (Psyllium Seed, Plantain Seed, Flea Seed) are the source of the French and Spanish Psyllium of commerce and are popular mostly in Europe. They are considered inferior to those of *P. ovata* because they have much lower mucilage content. The seeds (1.3–2.7 mm. × 0.6–1.1 mm.; 100 seeds weigh 0.09–0.14 g.) are ovate to ovate-elongate, concavo-convex, light brown to moderate brown, very glossy, nearly odourless and have a bland mucilaginous taste. One gramme of seeds agitated gently and occasionally with 20 ml. of water in a 25 ml. stoppered cylinder during 24 hours and then allowed to stand for one hour, occupies a volume of not less than 14 ml. (U.S.D., 1955, 1070; Steinmetz, II, 366; B.P.C., 1963, 684).

The dried, ripe seed is used as a laxative in the treatment of chronic constipation. It acts as a bulk-providing medium and is taken (dose, 4–16 g.) with a draught of water. Seed preparations are used to assist the production of smooth solid faecal mass after colostomy. The seeds are also demulcent and expectorant. Seed husk is useful in rheumatism and inflammation. Preparations of seed administered to rabbits in doses of 2 ml./kg. hastened the blood clotting process (B.P.C., 1963, 684; Hoppe, 711–12; *Chem. Abstr.,* 1955, **49,** 8490).

The seeds contain mucilage (10–12%) as the major constituent, together with a fatty oil, protein, oxalic and mucic acids, invertase, emulsin and the glyco-

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FIG. 53—PLANTAGO PSYLLIUM—FLOWERING BRANCH

side aucubin. The mucilage can be extracted from the seeds or seed coat with cold or boiling water, its composition depending on the method of preparation. It is composed of xylose, arabinose and galacturonic acid, the first being the principal sugar. The mucilage is readily dispersed in water, and is odourless and tasteless. Psyllium mucilage acts as a thickener and can be employed as a protective colloid. It finds application in the sizing of silk, manufacture of paper, and as a substitute for gum arabic or tragacanth in dye printing. It is suitable for use in preparations for the care of skin and hair, and as a waterproofing agent in explosive compositions. Ground seed husk can be used as a stabilizer in ice-creams (U.S.D., 1955, 1070; Mantell, 131–36; Smith & Montgomery, 367–68; Mantell, *Econ. Bot.*, 1949, **3**, 22; *Chem. Abstr.*, 1957, **51**, 720; 1943, **37**, 4856; 1950, **44**, 10199).

The seeds yield *c.* 7 per cent of a fatty oil having the following characteristics: $d^{15°}$, 0.924; $n^{25°}$, 73.2; sap. val., 191; ether val., 181; R.M. val., 1.94; Polenske val., 7.67; iod. val., 124; and unsapon. matter, 1.21%. The oil contains: free acids (as oleic), 5.04; soluble acids (as butyric), 0.82; and insoluble acids, 94.0%. It may be mixed with linseed oil and used in the preparation of varnishes. The oil cake is suitable as a feed (Eckey, 757–58; *Chem. Abstr.*, 1940, **34**, 2625).

The husk is reported to be eaten as an article of diet in West Pakistan. It is gathered dry from the wild plants and is consumed either raw or cooked. Analysis of the husk gave the following values: moisture, 8.30; protein, 1.40; ether extr., 3.40; available carbohydrates, 84.55; fibre, 0.35; and ash, 1.98%; phosphorus, 57.8 mg.; calcium, 305.9 mg.; iron, 18.3 mg.; and vitamin A potency, 4,000 I.U./100 g. (Baloch & Hajjatullah, *Pakist. J. sci. industr. Res.*, 1966, **9**, 87).

P. erosa Wall. ex Roxb. syn. *P. major* Hook. f. (Fl. Br. Ind.) in part, is a perennial herb found in Nepal, Sikkim, Khasi hills and Manipur. It possesses properties similar to *P. major* and is used almost in the same way.

P. himalaica Pilger syn. *P. brachyphylla* Edgew. is a perennial herb found in the Himalayas from Kashmir to Nepal at altitudes of 2,700–3,900 m. The leaves of the plant, slightly bruised, are used as an external application for wounds.

Plantain — *see* **Musa**

Plasma — *see* **Quartz and Silica**

Platanthera — *see* **Habenaria**

PLATANUS Linn. (*Platanaceae*)

A small genus of trees distributed in North America and from South-East Europe to West Asia. One species is cultivated in India.

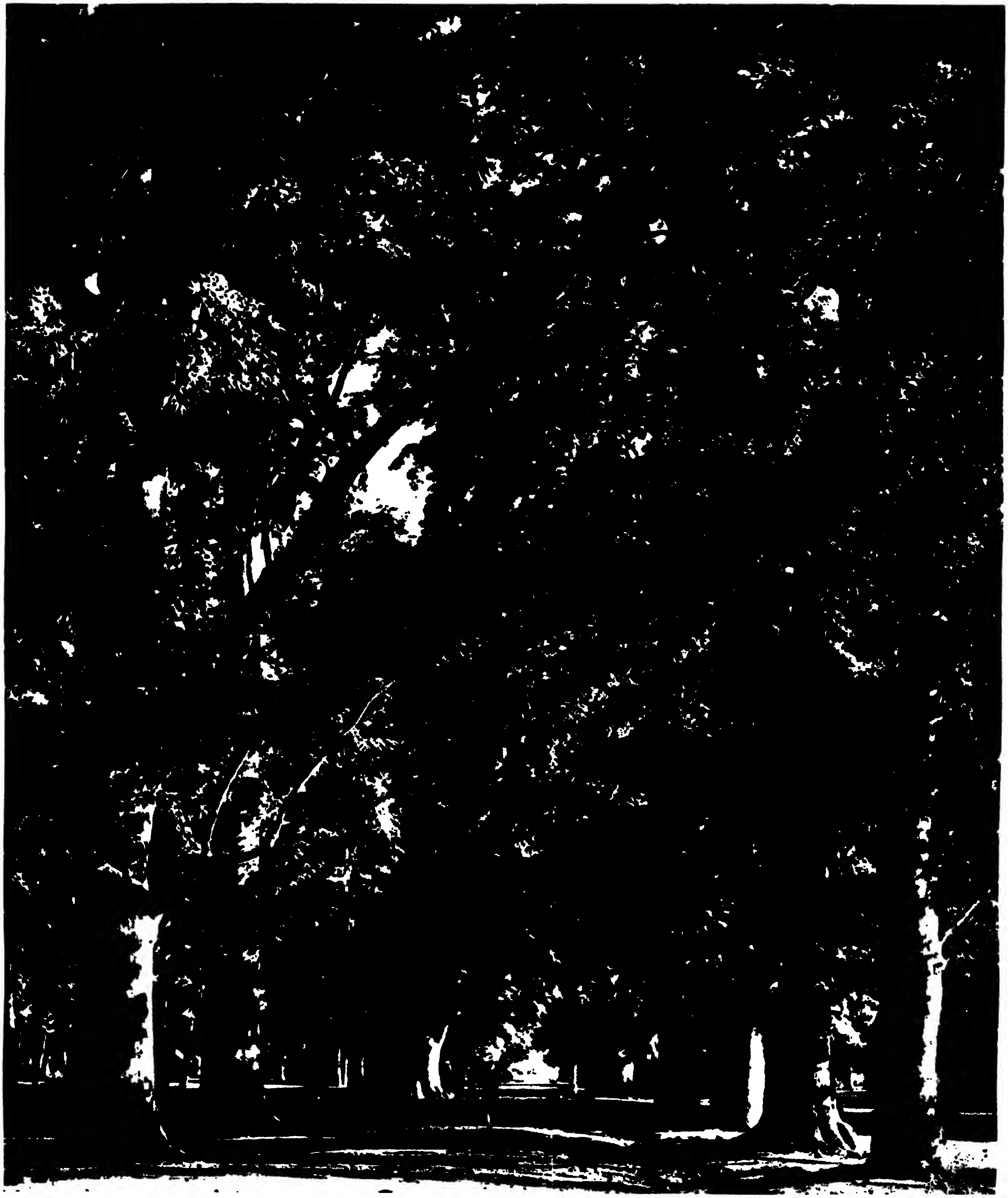
P. orientalis Linn. ORIENTAL PLANE

D.E.P., VI(1), 288; Fl. Br. Ind., V, 594.

KASHMIR & N. W. HIMALAYAS—*Chinar, buna, bonin.*

A large, graceful, deciduous tree, up to 30 m. in height and 12 m. in girth, cultivated chiefly in North-West Himalayas from Sutlej westwards at altitudes of 1,200–2,400 m. Bark greyish, exfoliating in large flakes; leaves palmately 5–7-lobed, 12–20 cm. long, often broader than long; flowers monoecious, in dense, unisexual, globose heads; fruiting head, *c.* 3 cm. in diam., consisting of numerous, small, 1-seeded achenes.

The plane tree is a native of eastern Mediterranean region from where it spread eastwards. It is commonly cultivated and highly valued as an ornamental tree in Kashmir. It has a short trunk and a roundish spreading crown and is mostly grown for shade in parks and on the roadside. It is seldom felled and is allowed to grow to large dimensions. The tree prefers moist deep well-drained soil and grows best near springs or streams; it is quite frost hardy. It may be easily propagated by nursery-raised seedlings, cuttings and layering. Seeds, which are small and light, are mixed with sand, loam and water and spread over well-raised nursery beds of fine soil containing considerable sand; they may also be sown in boxes. The year-old seedlings are preferred for transplanting, though larger plants can also be transplanted without difficulty. The best method of preparing cuttings is to tear off twigs about 30 cm. long and 2.5–5.0 cm. in diam. so that a strip of the parent branch remains at their base; they should be planted fairly deep. The tree grows fairly fast, the mean annual girth increment being *c.* 2.5 cm. It is affected by the leaf spot diseases caused by *Stigmina platani* (Fuckel) Sacc. and *S. visianica* Sacc. The dead wood is reported to be attacked by the beetles *Capnodis miliaris* Klug., *Aeolesthes sarta* Solsky and *Batocera rufomaculata* De Geer. [Troup, III, 893–94; Chaturvedi, *Indian Fmg, N.S.*, 1957–58, **7**(5), 28; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 282; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 42].



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PLATANUS ORIENTALIS—AN AVENUE

The wood is white, tinged with yellow or red; heartwood not distinct, fine-grained, moderately hard and heavy (wt. *c.* 657 kg./cu.m.), but not strong. It warps during seasoning and is durable only under cover. It is easy to saw and presents a decorative figure when quarter sawn. It can be finished to a smooth surface which takes a beautiful polish. In Kashmir, the wood is mostly used for small boxes, trays and similar articles which are lacquered and painted. In West Asia and Europe, it is used for cabinet-making, furniture, veneers, carving, coach-building, general turnery and for wood pulp. It has been reported to be suitable for boot lasts (Gamble, 661; Titmuss, 109; Streets, 616; Uphof, 286; Ishaq, *Pakist. J. For.*, 1957, **7,** 20).

The bark possesses antiscorbutic and antirheumatic properties. Boiled in vinegar, it is given in diarrhoea and dysentery. Bruised fresh leaves are applied in ophthalmia. The bark contains 1.5 per cent of platanin; it also contains 5.9 per cent tannin and 7.3 per cent non-tans. The shoots and leaves contain allantoin; phlobaphene (6%) has been reported from the roots. The sap of the tree contains up to 90 per cent mannitol. A substance which shows gibberellin-like activity in tests on dwarf peas, has been separated from the buds. Platanolic acid, a triterpene, is found in most parts of the plant except in the fruits. Platanolic acid, platanin and platanol, isolated from this plant by various workers, are all probably identical with betulinic acid (Steinmetz, 1957, 866; Kirt. & Basu, III, 2346; Wehmer, I, 433, suppl., 164; *Chem. Abstr.*, 1964, **61,** 8622, 8826; 1949, **43,** 730; 1950, **44,** 8061; Tej Singh *et al.*, *Indian For.*, 1958, **84,** 571).

PLATINUM MINERALS

D.E.P., VI(1), 288.

Hindi—*Safed sona.*

Platinum occurs in nature generally in the metallic condition, and with it, in varying proportions, five other elements, viz. ruthenium, rhodium, palladium, osmium and iridium, are usually associated. This group known as platinum metals is assuming increasing industrial importance because of their thermal, electrical, catalytic and corrosion-resistant properties. The major part of *c.* three million troy ounces of the world production is consumed by chemical and electrical industries and a comparatively minor portion is used for jewellery and decoration.

The platinum metals occur as native alloys with one another, both in primary deposits and in placers. Native platinum (alloy containing over 50% Pt) is found generally in very small quantities, as grains or scales or nuggets, widely distributed throughout the world, particularly in the U.S.S.R. (Perm district in Urals), Colombia, Abyssinia, U.S.A., Australia and Canada. Palladian is a native platinum containing 37 per cent palladium. Native palladium resembles native platinum in appearance and contains small quantities of platinum and iridium. Iridium is also found associated with platinum in platiniridium and with gold and osmium in aurosmiridium. Iridium is most often alloyed with osmium in iridosmine (Ir>Os) and siserskite (Os>Ir). Rhodium is a minor constituent of native platinum. The minerals which bear platinum metals include sperrylite ($PtAs_2$), cooperite (PtS), braggite (Pt, Pd, Ni)S, stibiopalladinite (Pd_3Sb), potarite (PdHg) and laurite (RuS_2) (Beamish *et al.* in Hampel, 305–07).

The primary deposits of platinum metals are of two main types. The first type occurs as disseminations or local concentrations of the metals in olivene-rich rocks, particularly in dunite, often associated with chromite. The placers are formed as a result of erosion of these deposits. Extensive deposits of this type occur in the Ural mountains and in Overwacht in Transvaal (Union of South Africa). The second type of primary deposits includes the magmatic nickel-copper sulphide deposits which are generally associated with norite, and make up the greatest known reserves of platinum metals. The most important deposits are in the norite belt of the Bushveld igneous complex in Transvaal and in the Sudbury district of Canada. The content of platinum metals is 4–10 p.p.m. in the Transvaal deposits, and 0.5 p.p.m. in the Sudbury ores (*Platinum Met. Rev.*, 1961, **5,** 105; Beamish *et al.* in Hampel, 305, 310).

The U.S.S.R., the Union of South Africa and Canada are the biggest producers and together account for over 90 per cent of the world production of platinum metals; U.S.A. and Colombia contribute small quantities (Table 1). A few kilograms have been produced in the Philippines. Platinum metals are reported to occur in some parts of India but the occurrence is of no commercial importance. The entire requirement of the country valued at Rs. 2–4 million a year is met by imports (*Emp. Commonw. Yearb.*, 1959–60, 551; *Mining Developments in Asia and the Far East, U.N. Mineral Resources Series,* No. 19, 1961, 63).

TABLE 1—WORLD PRODUCTION OF PLATINUM METALS*
(Qty in troy oz.)

	1962	1963	1964	1965	1966
U.S.S.R.	800,000	800,000	1,500,000	1,700,000	1,700,000
South Africa	305,603	305,185	604,135	753,820	784,000
Canada	470,792	357,653	376,238	452,063	396,059
U.S.A.	29,804	51,958	44,303	38,161	52,661
Colombia	14,100	22,983	20,647	11,141	..

* *Statist. Summ. Miner. Ind.*, 1960 65, 311 ; 1961 66, 305.

Distribution

In India, platinum metals have been reported to occur in minute quantities in gold washings from the sands of several rivers. In Assam, platinum and iridosmine were identified in gold concentrates obtained from the auriferous gravel of Noa-Dihing river, which drains the flanks of the Patkoi hills and Arakan Yomas. Flakes of platinum have been obtained from the samples of stream gold from Singhbhum and Manbhum districts of Bihar, and also from Brahmani river in Orissa. They have also been reported from Tavi river in Jammu & Kashmir, and Kolar district in Mysore. Platinum (0.6–1.3 p.p.m.) has been found in bauxite from the Tungar Hill near Bassein in Maharashtra. Alloyed with gold and copper, platinum occurs in association with bauxite in Dhangawan quarry about 55 km. from Jabalpur on the Katni road. Three samples of this bauxite on analysis showed 22, 15 and 11 p.p.m. of platinum respectively ; another set of analysis gave 35–39 p.p.m. (Coggin Brown & Dey, 142–43 ; Mallet, *Rec. geol. Surv. India*, 1882, **15**, 53 ; Dunn, *Mem. geol. Surv. India*, 1941, **78**, 233 ; Chhibber, *J. sci. industr. Res.*, 1947, **6B**, 81 ; 1945–46, **4**, 450 ; Sastri, ibid., 1947, **6B**, 82).

Extraction and Refining

The process of isolation of platinum metals from the Canadian ores is integrated with the process employed for the extraction and refining of nickel and copper from these ores. The platinum metals are recovered as by-product concentrates when the precious metal alloy, formed during the process, is subjected to electrolytic refining. From the South African ores, the concentrates of platinum metals are obtained by combined gravity and flotation concentration.

The concentrates are treated with aqua regia, and from this solution platinum and palladium are obtained respectively as ammonium chloroplatinate $(NH_4)_2PtCl_6$, and diammine palladium chloride $Pd(NH_3)_2Cl_2$. The residue is converted into a lead alloy, from which through a complicated method of separation, rhodium is isolated as ammonium (or potassium) nitritorhodite $(NH_4)_3Rh(NO_2)_6$, ruthenium as oxide RuO_2, osmium as osmyltetrammine chloride $OsO_2(NH_3)_4Cl_2$, and iridium as ammonium chloroiridate $(NH_4)_2IrCl_6$. Except platinum, which is obtained from the ammonium chloroplatinate on ignition in air, the other metals of the group are obtained from their salts by igniting them in an atmosphere of hydrogen. Platinum metals are also recovered from native alloys and the scrap derived from the old dental alloys, jewellery, laboratory equipment, spent catalysts and sweepings and spillage from refiners and electroplaters (Beamish *et al.* in Hampel, 310–14).

For melting platinum metals, zirconia- and thoria-lined crucibles are used in an induction furnace. Extremely pure platinum metal such as required for research or for certain electrical application is produced in a vacuum arc furnace with a water-cooled copper crucible and a tungsten electrode in argon atmosphere ; the gaseous impurity from the metal is removed through annealing in vacuum (Beamish *et al.* in Hampel, 315–16 ; *Platinum Met. Rev.*, 1963, **7**, 136).

Properties and Uses

All platinum metals are available in the form of sponge and as salts ; the largest portion of commercial production, however, consists of platinum and palladium. They share almost equally about 96 per cent of the total consumption of these metals. They are obtained in the form of sheet, wire, foil, and ribbon of various grades of purity. The industrial application of these metals depends chiefly upon their high fusing points and their resistance to chemical attack.

Platinum (m.p., 1773.5° : d, 21.37) is a greyish white metal softer than silver : it is hardened by alloying with other metals. The purest platinum (99.99%) is used for resistance thermometers and thermo-couples. Platinum is used for surgical tools, standard weights and measures, laboratory-ware and lining the reaction vessels in chemical industry. Platinum-clad anodes are used in electrolytic work, often for the large over-potential of oxygen on them ; an alloy with iridium (10%) is employed in the manufacture of peroxyborates, perchlorates, and

peroxysulphates. In glass industry, platinum is used as a colourant and alloyed with rhodium in the equipment for handling molten glass. Finely divided platinum is used as catalyst in the manufacture of sulphuric and nitric acids, reformation of petroleum, certain hydrogenation reactions and purification of gases.

Platinum is employed in electrical industry for contacts and sometimes fuses. It is used alloyed with ruthenium, palladium or tungsten for spark plug electrodes of aircraft engines; with tungsten (4%) for radar tube grids, with nickel as base for thermionic cathodes coated with metallic oxides, with rhodium (10–20%) for windings in high temperature furnaces, and with cobalt (*c.* 50%) for powerful ferro-magnets fitted in electric watches with permanent magnet-motor. Considerable quantity of platinum hardened with iridium (5–10%), ruthenium (5%) or copper (3–5%), is used in jewellery; white gold is an alloy of gold with small percentage of platinum. A hard alloy with iridium (25–30%) is used in pen tubings, hypodermic needles, radium applicators and various small accessories (Beamish *et al.* in Hampel, 316–31; Banerjee, *Proc. nat. Inst. Sci. India*, 1953, **19**, 291; 1954, **20**, 19; van Nostrand, 1958, 1274).

Palladium (m.p., 1553°; d, 12.16), because of its lower price and density, replaces platinum wherever feasible. Alloyed with silver (40%) or copper (40%), it is used for electric contacts carrying low currents, and with gold (*c.* 50%) for temperature-limiting fuses. Other alloys with these metals or platinum are used in dentistry. A moderate amount of palladium alloyed with ruthenium (4.5%) or ruthenium and rhodium (4 and 1% respectively) is used in jewellery; palladium produces whiter gold than platinum. As a catalyst, palladium is mainly effective in hydrogenation reactions and is used in the synthesis of a number of chemical products. Addition of 0.1–1.0 per cent of palladium or platinum to 18-9 stainless steels makes them resistant to sulphuric acid, and 0.1 per cent palladium in titanium protects it against boiling sulphuric and hydrochloric acids (Beamish *et al.* in Hampel, 331–32; van Nostrand, 1958, 1186).

Rhodium (m.p., 1985°; d, 12.44) provides a hard and lustrous surface and is used for electroplating sliding electric contacts, quality instruments, silver jewellery, mirrors and reflectors; it is also sublimed on to glass for making mirrors and interference filters for light. Ruthenium (m.p., 2450°; d, 12.06), mainly used as hardener for palladium and platinum, can be subjected to rolling, drawing and welding for the fabrication of simple components. A ruthenium-containing catalyst is used in specific cases for the reduction of carbonyl groups, even in the presence of an olefinic linkage. Iridium (m.p., 2350°; d, 22.42) is used in the production of alloys of great hardness, for tips of fountain pen nibs, long life phonograph needles and instrument pivots. Osmium (m.p., 2700°; d, 22.48) is used for the same purpose as iridium and is employed as a catalyser in the synthesis of ammonia (Beamish *et al.* in Hampel, 332–33; van Nostrand, 1958, 1419, 1444, 902, 1171; Rhys & Price, *Engelhard Inds tech. Bull.*, 1964, **5**, 37).

Imports and Prices

The platinum metals are imported from U.K., U.S.A., U.S.S.R. and Germany as worked or unworked metals and as salts. The import of platinum (Table 2) has shown marked increase in recent years. The value of palladium imported during 1963 (March December), 1964, 1966 (July–December), and 1967 was respectively Rs. 79,197, Rs. 128,284, Rs. 183,357 and Rs. 243,494. No import of palladium was recorded during 1965 (January–August) (*East. Met. Rev.*, 1964–65, **17**, 171; 1965–66, **18**, 169; 1966–67, **19**, 181; 1967–68, **20**, 179; 1968–69, **21**, 153).

The New York dollar prices per troy ounce for platinum metals in 1965 and 1966 were as follows: platinum, 97–100; palladium, 32–34; osmium, 300–350; rhodium, 182–185; and ruthenium, 55–60. The rupee price of U.S.A.-produced platinum per troy ounce in 1965, 1966 and 1967 was 460–480, 465–750 and 750–840 respectively [*Indian Miner.*, 1965, **19**, 204; 1966, **20**, 118; *Indian Min. & Engng J.*, 1965, **4**(2), 11; 1965, **4**(6), 11; 1966, **5**(1), 11; 1966, **5**(6), 17; 1967, **6**(1), 7; 1967, **6**(6), 6].

TABLE 2—IMPORTS OF PLATINUM

Year	Qty (kg.)	Val. (thousand Rs.)
1961*	119	1,353
1962*	112	1,360
1963*	191	1,836
1964*	362	3,789
1965†	219	2,442
1966†	131	2,314
1967†	152	3,022

* *Indian Miner. Yearb.*, 1964, 168.
† *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11 & 12), I:49; 1967, **7**(11 & 12), I:51.

*PLATOSTOMA Beauv. (*Labiatae*)

A small genus of herbs distributed in India and tropical Africa. One species has been recorded in India.

P. africanum Beauv. syn. *P. flaccidum* Benth.

Fl. Br. Ind., IV, 611; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 34.

An erect, slender annual, 10–30 cm. high, found in Orissa, Konkan and Mysore at altitudes of 300–1,000 m. Leaves membranous, ovate, serrate; flowers pale blue or lilac, in racemes; nutlets brown or black, ovoid, minutely reticulated.

The plant possesses a slight mint- or sage-like odour. In North Nigeria, it is used for fever. The leaves are given as local haemostatic in South Nigeria. In Ghana, the leaves and seeds are used for cough; they are also chewed with salt to cure sore throat. The root is mixed with *Tephrosia linearis* Pers. to make a decoction for treating feverish chills and rheumatic symptoms (Dalziel, 463).

PLATYCODON A.DC. (*Campanulaceae*)

Bailey, 1947, III, 3711, Fig. 3066.

A monotypic genus, represented by *P. grandiflorum* A.DC. distributed in East Asia. It is an erect, hardy herbaceous perennial, 40–60 cm. high, introduced into India and cultivated in rockeries and borders. It bears lanceolate leaves and blue, lilac or white flowers.

The plant is a native of China and Japan and is raised from seeds. It produces thick roots, which live for a number of years producing annual shoots. The roots constitute an important drug. The root possesses a haemolytic action due to the presence of a saponin (*c.* 2%), platycodin ($C_{12}H_{68}O_{17}$, m.p. 230–31°), which on hydrolysis yields an inactive sapogenin, platycodigenin ($C_{30}H_{48}O_7$, m.p. 242–43°), and glucose. The action is stronger in the case of peeled roots and roots obtained from wild and violet-flowered plants. The saponin is fatal to mice in doses of 60–70 mg./100 g. body weight. Aqueous extract of the roots is reported to be toxic to fish. The plant is reported to contain inulin and resinous substances (Gopalaswamiengar, 454; *Chem. Abstr.*, 1933, **27**, 4831; 1939, **33**, 6448; 1937, **31**, 7599; 1940, **34**, 137, 767; 1954, **48**, 4178; Roi, 299).

The root is considered tonic, astringent and carminative. It is used as an expectorant; in Japan, it is given as anti-bronchitic, and in Indo-China, as sedative in cough and throat ailments. It is sometimes chewed along with the roots of liquorice, or used as a decoction prepared from both the roots. The plant in combination with other plants and laxatives enters into a preparation reported to be used in indigenous medicine in China in the treatment of appendicitis (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 277; Roi, 299; *Quart. J. Crude Drug Res.*, 1963, **3**, 437).

* This is wrongly spelt as *Platystoma* Beauv. in many floras.

PLECOSPERMUM Trec. (*Moraceae*)

A small genus of shrubs and trees distributed in Malagasy, India and Burma. Two species occur in India.

P. spinosum Trec.

D.E.P., VI(1), 290; Fl. Br. Ind., V, 491; Alston, Fig. 183.

Tel.—*Koriti, kodiari, alasale;* Tam.—*Achingudi, daiyal;* Kan.—*Bendaka;* Oriya—*Banabana.*

Eastern Himalayas—*Gumbenfong, mainakat-lara, maidal-lara.*

A large, straggling, thorny shrub or small tree found in eastern Himalayas and Deccan Peninsula up to an altitude of 1,200 m.; records of its occurrence in the sub-Himalayan tracts of Punjab and Uttar Pradesh lack confirmation. Bark orange-brown, peeling off in thin flakes; leaves obovate or elliptic-oblong; flowers in heads, small, dioecious; fruiting heads fleshy, lobed, *c.* 1.25 cm. in diam.

The plant is found in open places and as hedges. It has a slow rate of growth with a mean annual girth increment of *c.* 1.3 cm. The sapwood is greyish; heartwood small, orange-yellow, containing yellow resinous matter, very hard and heavy (wt., 801 kg./cu.m.). The wood is reported to be suitable for tool handles and ornamental cabinet-work and is good fuel. Bark and wood have been reported to be used in Darjeeling Terai for dyeing silk yellow (Gamble, 634; Lewis, 352).

P. andamanicum King ex Hook. f. is a large, woody, climber with stem, up to 15 cm. in diam., commonly found in forests of the Andaman Islands. It yields a very hard wood (Parkinson, 256).

PLECTOCOMIA Mart. & Blume (*Palmae*)

D.E.P., VI(1), 290; C.P., 202; Fl. Br. Ind., VI, 477.

A small genus of scandent spinous rattans distributed in Indo-Malaysian region. Four species occur in India.

P. himalayana Griff. (Nepal—*Tokribet;* Lepcha—*Runool*), with long stem (diam., *c.* 2.5 cm.) and

large pinnate, prickly, flagelliferous leaves, is very common in Sikkim and Darjeeling hills at altitudes of 1,200–2,100 m. It yields soft canes occasionally used for tying fences and for rough basket work. It is also reported to be suitable for making crooks of umbrella handles (Blatter, 275; Badhwar *et al.*, *Indian For.*, 1961, **87**, 257).

P. assamica Griff. found in upper Assam and *P. khasyana* Griff. of Khasi hills are probably used like other canes.

*PLECTRANTHUS L'Herit. (*Labiatae*)

A large genus of herbs or undershrubs distributed in tropical and sub-tropical Asia, Africa, Australia and Polynesia. About forty species occur in India.

P. mollis Spreng. syn. *P. incanus* Link

Fl. Br. Ind., IV, 621; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 47.

BOMBAY—*Lal-agada*; MUNDARI—*Bir sikinri ba.*

An erect coarse herb or undershrub, 30–120 cm. high, found in the temperate Himalayas from Simla to Sikkim up to an altitude of 1,750 m., and in Khasi hills, Bihar, Madhya Pradesh, Deccan, Carnatic and western ghats (900–1,800 m.). Leaves ovate-cordate, acute or acuminate, crenate; flowers pale lilac or light blue, in lax-flowered cymes in racemes; nutlets sub-globose, smooth, pale brown, dotted with dark spots.

The leaves and flowering tops of the plant gave (0.2 ml./100 g.) an essential oil having the following characteristics: sp. gr.$^{21.5}$, 0.8976; $n^{21.5°}$, 1.4900; $[\alpha]^{20.5°}$, −11.71°; acid val., 4.18; and ester val., 41.67. The oil exhibited activity against *Bacillus subtilis*, *B. dysenteriae*, *Micrococcus pyogenes* var. *aureus*, *M. pyogenes* var. *albus*, *Escherichia coli*, *Salmonella typhosa* and *Vibrio comma*; the activity of 10 mg. of the oil was found to be the same as that of 10 units of penicillin G sodium. The essential oil possessed also a cardiac depressant, respiratory stimulant, and vaso-constrictor action. It exhibited relaxant activity on smooth and skeletal muscles. Leaves and flowering tops contain, in addition to the oil, resin and tannin (Varma & Sharma, *Indian J. Pharm.*, 1963, **25**, 189; Sharma & Ali, ibid., 1966, **28**, 31).

The crushed leaves of the plant are used in Chota Nagpur to stop bleeding and to cure fever. They are also used as mosquito repellent (Bressers, 120).

* A number of species of this genus have been transferred to the genus *Isodon* Schrad. (Kudo, *Mem. Fac. Sci. Agric., Taihoku*, 1929, **2**, 37; *Proc. Jap. Ass. Advanc. Sci.*, 1929, **5**, 157; Codd, *Taxon*, 1968, **17**, 239).

FIG. 51—PLECTRANTHUS MOLLIS—FLOWERING BRANCH

P. rugosus Wall.

D.E.P., VI(1), 291; C.P., 124; Fl. Br. Ind., IV, 620; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 47.

KASHMIR—*Solei*; PUNJAB—*Chhichhri, bui, piumar*; KUMAUN—*Kurkha.*

An erect, aromatic shrub, 60–180 cm. high, found gregariously in the western Himalayas from Kashmir to Garhwal at altitudes of 900–2,800 m., and in Bhutan, Mt. Abu and Madhya Pradesh. Leaves ovate or elliptic, obtuse crenate; flowers white with rose or purple spots, in axillary cymes; nutlets oblong.

The leaves of the plant are exceedingly aromatic and contain small quantities of an essential oil; the oil content can be increased by proper cultivation. The plant is reported to be used in some places to keep off fleas. In Simla, it is believed that the best honey is procured from localities where *P. rugosus* abounds.

P. macranthus Hook. f. is a sparsely hairy, perennial shrub, 15–30 cm. high, with ovate or elliptic-lanceolate, serrate leaves and white flowers found in Sikkim and Khasi hills at altitudes of 1,500–2,400 m.

The whole plant is crushed into a plaster used as an antiseptic for sores (Cheo, *Bot. Bull. Acad. sinica*, 1947, **1**, 307).

Plectranthus spp. — *see* **Microtaena**

Plectronia — *see* **Canthium**

PLEIOGYNIUM Engl. (*Anacardiaceae*)

A small genus of trees distributed in Australia. One species has been introduced into India and grown as an ornamental plant.

P. timoriense (DC.) Leenhouts syn. *P. solandri* Engl. BURDEKIN PLUM

*Parker, 119; Barrett, M.F., 74, Fig. 10.

A handsome evergreen tree, 12–18 m. high, indigenous to Queensland (Australia) and cultivated as an ornamental tree in Lucknow and Saharanpur in Uttar Pradesh and Kapurthala in Punjab. Bark dark-grey, smooth, flaking, horizontally ridged; leaves imparipinnate or by abortion paripinnate: leaflets obliquely ovate or oblong, entire; flowers greenish or yellowish, in axillary lax panicles; fruit a drupe of the size of a cherry, purple, with white or reddish, sweet and acid pulp and a large stone; seeds oblong, slightly curved outwards.

The fruit of the plant is used in making jams and jellies. The seeds possess a pleasant flavour and are consumed in Australia. The wood resembles walnut and can be similarly used. The timber, when first cut, is soft but afterwards becomes hard and tough. The plant can be used as a stock for less hardy anacardiaceous fruit-bearing trees. The inner layer of the bark, in considerable concentration, acts as a temporary stupefacient to fish (Barrett, M.F., 74; Uphof, 287; Bailey, 1947, III, 2713; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 15).

Pleiospermium — *see* **Hesperethusa**

PLEOPELTIS H. & B. (*Polypodiaceae*)

Beddome, Indian Ferns, 344; Copeland, 183.

A genus of ferns found mainly in tropical America, and from Japan to Africa. Beddome mentions 28 spp. from India, but many of these species have been transferred to other genera, including *Microsorium*, *Phymatodes*, *Pyrrosia* and *Lepisorus*.

*In the later editions of his Flora, Parker (1924, 560; 1956, 116) changed the name to *P. cerasiferum* Parker based evidently on *Owenia cerasifera* Muell. with which it was thought identical. As the later name is valid for a plant of the family *Meliaceae*, the combination *P. cerasiferum* appears to be incorrect.

P. lanceolata (Linn.) Kaulf. syn. *Polypodium lanceolatum* Linn. is a fern with long creeping, paleaceous rhizome found in the southern parts of western ghats and in the Nilgiri hills; it has also been recorded from Assam. A decoction of the fern is used in South Africa for colds and sore throat. In Mexico, a tea prepared from the fronds is used for itch (Watt & Breyer-Brandwijk, 1089; Kirt. & Basu, IV, 2748).

PLESMONIUM Schott (*Araceae*)

A monotypic genus, represented by *P. margaritiferum*, distributed in India.

P. margaritiferum Schott

Fl. Br. Ind., VI, 518; Kirt. & Basu, Pl. 1001.

BENG.—*Gajeer mul.*

UTTAR PRADESH *Kharhar*; MADHYA PRADESH—*Jalulija, bansur*; MUNDARI—*Bir hada*.

A tuberous herb found in upper Gangetic plain, Madhya Pradesh, Bihar, Central Bengal and Andhra Pradesh. Tubers large, hemispherical, up to 15 cm. diam., white, covered with warts; leaf solitary, rarely two, trifoliolate: leaflets narrowly lanceolate, sometimes forked; spathe leathery; spadix stout, as long as the spathe; flowers monoecious, in cylindric inflorescence; fruits red, ovoid.

The tubers of the plant are poisonous; however, they are eaten after several boilings with tamarind pulp or acid. The Mundas rub the well-ground tubers on swellings of the extremities. The crushed seeds have a benumbing effect and are used in Goa for toothache and as an external application to bruises (Bressers, 132; Kirt. & Basu, IV, 2612; Caius, *J. Bombay nat. Hist. Soc.*, 1936–37, **39**, 138).

PLEUROSTYLIA Wight & Arn. (*Celastraceae*)

Fl. Br. Ind., I, 617; Fl. Malesiana, Ser. I, **6**(2), 287, Fig. 20.

A small genus of trees or shrubs distributed in South Africa, Malagasy, Mascarene Islands, Indo-Malaysian region and New Caledonia. One species occurs in India.

P. opposita Alston syn. *P. wightii* Wight & Arn. (TEL.—*Piyari*; TAM.—*Chiru piyari, karuvali*) is a large shrub or small handsome tree with oblong-lanceolate to somewhat ovate leaves and small, ovoid, white fruits found in the Deccan Peninsula, chiefly in the hills. Wood is light red or greyish, close- and even-grained, smooth, moderately hard and heavy (wt., 769 kg./cu.m.). It is reported to be a beautiful

furniture wood and is used in Cuddapah for making combs. Occurrence of a toxic alkaloid is reported in the plant; the leaves contain quercitrin (Gamble, 175; Bor, 226–27; Burkill, II, 1772; Wehmer, II, 717).

Plovers — *see* **Birds**

PLUCHEA Cass. (*Compositae*)

A genus of shrubs or undershrubs, rarely herbs, distributed in the tropical and sub-tropical regions of the world. Six species have been recorded in India.

P. indica Less.

D.E.P., VI(1), 291; Fl. Br. Ind., III, 272; Kirt. & Basu, Pl. 523A.

BENG.—*Kukronda, munjhu rukha.*

A low shrub found in salt marshes and mangrove swamps in Sundarbans. Leaves 2–5 cm. long, obovate or oblanceolate, sub-serrate, narrowed into a short petiole; flowers lilac, in heads in terminal corymbs.

The plant is drought resistant and grows on heavy soils. The leaves, flowers and young tops are eaten raw or cooked. In Thailand and Java, the aromatic leaves are used as a flavouring. Leaves contain 2.9 per cent protein. The plant contains chlorogenic acid (Uphof, 287; Burkill, II, 1773; Terra, *Commun. R. trop. Inst. Amst.*, No. 54c, 1966, 68; Wehmer, II, 1213).

The roots and leaves are reported to possess astringent and antipyretic properties and are given in decoction as a diaphoretic in fevers. Leaf juice is taken for dysentery in Malaya. In Indo-China, an infusion of leaves is given for lumbago; it is also used as a remedy against leucorrhoea. The leaves are used in baths (as nervine tonic), in poultices against atonic and gangrenous ulcers. In Malaya, the leaves are used as a constituent in tea, for slimming. Recently, a hybrid of this species with *P. odorata* Cass. has been reported; the latter is a medicinal plant of Central America (Kirt. & Basu, II, 1345; Burkill, II, 1773; Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 19; Hoppe, 714; Cooperrider & Galang, *Amer. J. Bot.*, 1965, **52,** 1020).

P. lanceolata C. B. Clarke

D.E.P., VI(1), 291; Fl. Br. Ind., III, 272; Kirt. & Basu, Pl. 523B.

HINDI, MAR. & GUJ.—*Rasana, rashana.*

PUNJAB—*Sarmei, reshami;* UTTAR PRADESH—*Baisurai;* RAJASTHAN—*Chotakalia;* DELHI—*Rukhri.*

An erect undershrub, 30–100 cm. tall, found in sandy or saline soils in Punjab, upper Gangetic plain, Rajasthan and Gujarat. Leaves 2–6 cm. long, sessile, oblanceolate or oblong, coriaceous; flowers white, yellow, lilac or purple, in many headed compound corymbs.

P. lanceolata occurs gregariously in vast areas in dry tracts forming thickets and is considered a troublesome weed. It does much damage to rabi crops, particularly in areas where irrigation facilities are not available. The plant is succulent when young, with sufficient foliage, and, on this account, it has been tried as a possible cattle fodder in some of the drier parts of Uttar Pradesh. Cattle, however, avoid it when grazing, because of its peculiar disagreeable bitter taste. It can be fed only to working cattle either in mixture with *bhusa* or jowar stalks. Analyses show a fairly high percentage of protein and a much greater feeding value than *bhusa* or jowar stalks. Bullocks fed on *baisurai*-jowar mixture show a sleek well-fed appearance (Parr & Dayal, *Agric. J. India*, 1921, **16,** 106; Parr & Lal, ibid., 1921, **16,** 206).

FIG. 55—PLUCHEA LANCEOLATA—FLOWERING BRANCH

As a troublesome weed, it can be eradicated by spraying Agroxone (10%) or Fernoxone (2, 4-D) [Shivapuri & Tyagi, *Indian Fmg*, 1950, **11**, 116; Tandon, *Agric. Anim. Husb., Uttar Pradesh*, 1951, **1**(9), 9].

The leaves are succulent and are considered aperient; they are used as substitute or adulterant for senna. The plant is mentioned in Ayurvedic texts to be used in diseases similar to rheumatoid arthritis. A decoction of the plant has been reported to prevent the swelling of joints in experimental arthritis. Preliminary studies on the plant revealed the presence of glycoside and sterol. Pharmacological investigations indicated that the drug had two primary actions, viz. acetylcholine-like action and smooth muscle relaxant-spasmolytic action on different muscle preparations. The only central nervous system activity detected in the drug was that of potentiation of barbiturate hypnosis. In a recent investigation, quercetin and *iso*rhamnetin were identified in the air-dried leaves; glycosides were absent (Singh, *Indian J. agric. Sci.*, 1945, **15**, 297; Kirt. & Basu, II, 1345; Chaturvedi & Singh, *Indian J. med. Res.*, 1965, **53**, 71; Prasad *et al.*, ibid., 1966, **54**, 582; 1965, **53**, 1062; Bahl *et al.*, *Curr. Sci.*, 1968, **37**, 1).

Plum — *see* **Prunus**

Plum, Black — *see* **Syzygium**

Plum, Coco — *see* **Chrysobalanus**

Plum, Date — *see* **Chrysophyllum**

Plum, Governor's, Madagascar or Puneala — *see* **Flacourtia**

Plum, Hog or Jew — *see* **Spondias**

PLUMBAGO Linn. (*Plumbaginaceae*)

A small genus of herbs, undershrubs or shrubs distributed in the tropics. Three species are recorded from India of which two are considered medicinally important.

P. indica Linn. syn. *P. rosea* Linn.

D.E.P., VI(1), 294; Fl. Br. Ind., III, 481; Fl. Malesiana, Ser. I, **4**(2), 111, Fig. 2.

HINDI—*Chitra, lal-chita, rakta-chitra*; BENG.—*Lal-chitra*; MAR.—*Lal-chitrak*; GUJ.—*Lal-chitrak, rato-chatro*; TEL.—*Errachitramulam*; TAM.—*Cenkodi-veli, cithiramulam*; KAN.—*Kempacitramulam*; MAL.—*Chivappukoduveli*; ORIYA—*Rongachitamulo, lal-chita*.

KASHMIR—*Shitray, shitranj*; ASSAM—*Agechhit*.

A shrubby perennial found growing throughout India often as a cultivated plant or as a garden escape. Leaves broadly ovate or elliptic, dark green above, pale below; flowers red, in terminal and axillary racemes.

P. indica is a pretty ornamental plant, frequently grown in gardens for its showy bright red flowers. It is widely distributed in tropics. It is reported to be wild or indigenous to Sikkim and Khasi hills, although in all Indian floras it has been reported only as cultivated or as an escape from cultivation. It has never been recorded wild in any accounts so far of plants from Sikkim or Khasi hills. On the other hand, it is stated to be always found in anthropogenic localities and locally run wild or persisting semi-spontaneously. Further, it is propagated only vegetatively by offsets or small cuttings and has never been known to be found in fruit. Many consider it as only a variety of *P. zeylanica* or as its cultigen. One form with bigger and brighter flowers is considered as var. *coccinea* of this species [Gopalaswamiengar, 283; Fl. Malesiana, Ser. I, **4**(2), 111].

The roots as well as the root bark of *P. indica* form an important indigenous drug, but less commonly used than those of *P. zeylanica*. The root is cylindrical, sometimes irregularly bent or curved, 60–90 cm. long and 1.3–2.0 cm. thick, light yellowish brown, smooth, often with short transverse shallow fissures at the region of bends. Dried roots are darker or nearly black (Burkill, II, 1774; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 4, 1960, 41).

The root bark of *P. indica* contains an orange yellow pigment named plumbagin (2-methyl-5-hydroxy-1,4-naphthoquinone, $C_{11}H_8O_3$, m.p. 77–78°), a sitosterol glycoside ($C_{35}H_{58}O_6$, m.p. 259–60°), a sitosterol, a fatty alcohol, probably arachidyl alcohol, tannin, and an amorphous brown pigment. Plumbagin is the active principle of the drug, and is present in both *P. indica* and *P. zeylanica* up to the extent of about 0.9 per cent. The concentration of plumbagin varies according to the locality, growth and age of the plant, condition of the soil, and the season of the year. The older the plant and drier the soil, the greater is the quantity of the active principle found in the root. The fresh roots give much higher yields of plumbagin than the roots stored for a long period (Roy & Dutt, *J. Indian chem. Soc.*, 1928, **5**, 419; Mayer & Cook, 106; Tumminkatti & Patwardhan, *J. Indian Inst. Sci.*, 1932, **15A**, 9; Chopra, 1958, 386).

Plumbagin, in small doses, has a stimulant action on central nervous system, on plain muscles, and on the secretion of sweat, urine and bile. Blood pressure shows a slight fall and the peripheral vessels are found to dilate. Stimulation is not properly observed in the isolated heart of the frog. With large doses, plumbagin causes paralysis leading ultimately to death, the minimum lethal dose for frog, mice and rabbit being 0.5, 0.1, and 10.0 mg./kg. respectively. Plumbagin in a dilution of 1 p.p.m. stimulates the isolated rabbit uterus, and at 10 times this concentration inhibits it. A suitable intraperitoneal injection in the pregnant rat results in foetal death and secondary ovarian malfunction. Studies on oxytocic effect of the aqueous extract of the roots on isolated rat uterus, isolated guinea-pig uterine strips and on isolated human uterine strips, indicate that the drug has a powerful action on uterus (Chopra, 1958, 386; Chopra *et al.*, I, 520–21; *Biol. Abstr.*, 1936, **10,** 15945; Misra *et al.*, *Labdev J. Sci. & Technol.*, 1966, **4,** 55).

Plumbagin acts as a powerful irritant and has well-marked antiseptic properties. In 20 p.p.m. dilution, it inhibits pathogenic fungi such as *Coccidioides immitis*, *Histoplasma capsulatum*, *Ctesnomyces radians*, and *Trichophyton ferrugineum*. It acts as an antimetabolite towards *Mycobacterium tuberculosis*. Preliminary studies have shown that plumbagin may be useful in the treatment of early cases of leucoderma and baldness of head (Chopra, 1958, 386; *Chem. Abstr.*, 1947, **41,** 6598).

The flowers contain 3-rhamnosides of pelargonidin, cyanidin, delphinidin and kaempferol (*Chem. Abstr.*, 1962, **56,** 12011).

The root is considered abortifacient, vesicant, and a powerful sialogogue. In Malaya, chewing the roots regularly with arecanut is said to cause abortion. Because of its vesicating properties it has been used in the treatment of certain types of leucoderma. In South India, it is valued as a remedy for secondary syphilis and leprosy. It has been recommended as an efficient substitute of cantharides. The bruised root is acrid and stimulating, but when tempered with a little bland oil it is used as an external application in rheumatic affections of joints and paralytic conditions. It is given internally in small doses for the same complaints in combination with other drugs; in large doses, it acts as an acronarcotic poison. A tincture of the root is used in dyspepsia, piles, flatulence, loss of appetite and other digestive complaints. In Java, the root is used as a veterinary medicine for expelling worms in horses (Chopra, 1958, 386; Kirt. & Basu, II, 1469–70; Nadkarni, I, 989; Burkill, II, 1775).

P. zeylanica Linn.

D.E.P., VI(1), 295; C.P., 49; Fl. Br. Ind., III, 480; Kirt. & Basu, Pl. 574A.

HINDI & BENG.—*Chita, chitarak, chitra*; MAR.—*Chitramula, chitraka*; GUJ.—*Chitaro, chitrak*; TEL.—*Agnimata, chitramoolam*; TAM.—*Cithiramulam*; KAN.—*Chitramula, vahni*; MAL.—*Tumba koduveli, vellakoduveli*; ORIYA—*Chitamulo, chitapru, krisanu, ogni.*

MUNDARI—*Birkitamuli, chitur.*

A perennial, sub-scandent shrub found wild in peninsular India and West Bengal and cultivated in gardens throughout India. Leaves ovate, glabrous; flowers white, in elongated spikes; capsules oblong, pointed, contained in viscid glandular persistent calyx.

This species is more widespread and common than *P. indica* and is possibly indigenous to South-East Asia. It contains 2n=24 chromosomes in contrast to 2n=12 in *P. indica* and other species [Fl. Malesiana, Ser. I, **4**(2), 109; Dahlgren, *Svensk bot. Tidskr.*, 1964, **58,** 172].

FIG. 56—PLUMBAGO ZEYLANICA—FLOWERING AND FRUITING BRANCH

The roots of *P. zeylanica* are said to constitute the original indigenous drug known to ayurvedic physicians. The dried roots, as sold in bazaar, occur as cylindrical pieces of varying length and less than 1.25 cm in thickness, reddish brown in colour with fairly thick shrivelled, smooth or irregularly fissured brittle bark marked here and there with small projections representing scars of rootlets. Roots have a short fracture, an acrid and biting taste and disagreeable odour (Burkill, II, 1775; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 4, 1960, 38).

The root bark of *P. zeylanica* contains plumbagin (distributed in most of the secondary cortex and medullary ray cells), free glucose and fructose (*c.* 2.7%), and enzymes protease and invertase. Investigations have indicated the usefulness of the root in stimulating digestive processes. The leaves and the stem contain volatile oil but little or no plumbagin (Iyengar & Pendse, *Indian J. Pharm.*, 1962, **24**, 290; *Curr. Sci.*, 1963, **32**, 261; Watt & Breyer-Brandwijk, 851).

The root appears to possess abortifacient and vesicant properties similar to those of *P. indica*, though to a much milder degree. Besides, it is diuretic, caustic and expellent of phlegmatic humours, and is useful in rheumatism. It is used as an irritant to the skin, in the treatment of dyspepsia, piles, anasarca, diarrhoea and skin diseases. The root paste is applied in order to open abscesses. A paste prepared with milk, vinegar or salt and water is used as an external application in leprosy and other skin diseases of an obstinate character. The drug is apt to cause abortion and in Malaya, even eating the leaves is said to cause similar action. In Africa, a cold infusion of the root is used for influenza and blackwater fever. A tincture of root bark is antiperiodic. Alcoholic and aqueous extracts of roots showed antibacterial activity against *Micrococcus pyogenes* var. *aureus*. The roots also possess antibacterial activity against *Salmonella typhi* and *Mycobacterium phlei*. An alcoholic extract has been found to be a very powerful aphicide [Kirt. & Basu, II, 1467; Chopra, 1958, 387; Burkill, II, 1775; Watt & Breyer-Brandwijk, 850; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42; Kurup, ibid., 1956, **15C**, 153; Atkinson, *Aust. J. exp. Biol. med. Sci.*, 1956, **34**(1), 17; *Annu. sci. Rep. Indian agric. Res. Inst.*, 1964, 153].

P. auriculata Lam. syn. *P. capensis* Thunb. is a small sub-scandent shrub with oblong or oblong-spathulate leaves and pale blue flowers, indigenous to South Africa and grown in gardens in India as an ornamental plant. It is suited for borders, as a decorative hedge, bedding plant and for pot planting. It is usually propagated by suckers or division of roots. It bears almost throughout the year a profusion of umbel-like clusters of pale azure-blue, very pleasing flowers [Fl. Malesiana, Ser. I, **4**(2), 111; Bor & Raizada, 163–64; Gopalaswamiengar, 283].

In Africa, the foliage of the plant is readily eaten by poultry and stock, particularly the sheep; it becomes poisonous to animals under certain conditions. A decoction of the plant is taken as a remedy for blackwater fever. The root is used as a styptic in scrofula; an infusion of it is considered emetic. The powdered root is taken as a snuff to relieve headache; it causes warts to disappear when smeared over them (Watt & Breyer-Brandwijk, 850).

The flowers of the plant contain azulein (5-methoxy quercetin 3-rhamnoside) and 3-rhamnosides of delphinidin (*Chem. Abstr.*, 1962, **56**, 12011; 1962, **57**, 7628).

Plumbago — *see* **Graphite**

PLUMERIA Linn. (*Apocynaceae*)

A genus of laticiferous trees and shrubs, native of tropical America; some ornamental species are grown in the warmer regions of the world. About eight species are reported from India, but owing to the overlapping of characters in some species, it becomes difficult to fix their identity. *P. acuminata* and *P. rubra* are commonly grown for their ornamental flowers.

P. acuminata Ait. syn. *P. acutifolia* Poir.; *P. rubra* Linn. var. *acutifolia* Bailey TEMPLE OR PAGODA TREE

D.E.P., VI(1), 297; Fl. Br. Ind., III, 641.

SANS.—*Kshira champa*; HINDI—*Golainchi*; BENG. —*Dalan phul, gorur champa*; MAR. *Khair champa, son champa*; GUJ.—*Rhada champo*; TEL.—*Nuru varahaalu, vaada ganneru*; TAM.—*Arali, kallimandharai*; KAN.—*Deva ganigile, kadu sampage*; MAL.—*Ezha-champakam, arali*; ORIYA—*Kat champa, golochi, torato*.

SANTAL—*Champa pungar, gulanj baha*; ASSAM—*Gulanchi, gunach*.

An evergreen or partly deciduous tree, *c.* 7 m. high, with fleshy branches and copious latex, grown for ornament almost all over India, particularly in the vicinity of religious places and burial grounds. Leaves oblanceolate or elliptic, 15–30 cm. or more long, borne at the end of the branches; flowers white

I.C.A.R., New Delhi

FIG. 57—PLUMERIA ACUMINATA—FLOWERING BRANCH

with yellow centre or cream-coloured, sometimes pink-flushed outside, in terminal panicles, highly fragrant; follicles divaricate, brownish black; seeds oblong, winged, with pappus.

This plant is considered to be a native of Mexico. It is reported to have been introduced from the Philippines and has become naturalized in India. According to some authorities, it is considered as a variety or a form of *P. rubra* Linn. Variations in size and colour of the flowers are known and a few cultivars are recognized. Some of these are suspected to be hybrids. The plant is propagated through cuttings. It sets seeds rarely in India. The plants raised from the seeds show a wide variation in characters, evidently being different strains (Merrill, *Chron. bot.*, 1946, **10,** 304; Watson *et al.*, *Amer. hort. Mag.*, 1965, **44,** 125; Firminger, 454; Cowen, 19; Vaid, *J. Bombay nat. Hist. Soc.*, 1964, **61,** 215; Cheema, *Indian J. Hort.*, 1965, **22,** 206; *Bull. nat. bot. Gdns, Lucknow,* No. 14, 1958).

The plant is mainly grown for its ornamental and fragrant flowers. The flowers have a sweet odour and are employed for the preparation of garlands and perfumes. They vary in their fragrance, from strong to mild and from refreshing to highly objectionable, and also in their keeping quality. The development of perfume continues for sometime even in the plucked flowers and enfleurage of fresh flowers gives best results. On steam distillation, the fresh flowers yield an essential oil (0.04–0.07%) with the following characteristics: $d_{28°}^{28°}$, 0.9685; $n_D^{28°}$, 1.4885; acid val., 20.2; sap. val., 123; and sap. val. after acetylation, 257. The oil consists mainly of primary alcohols (68% of saponified oil), viz. geraniol, citronellol, farnesol and phenylethyl alcohol, either free or esterified and some linalool; in another analysis, the presence of aldehydes or ketones (6.8%) is also reported. The essential oil possesses antifungal activity. The flowers contain quercetin and traces of kaempferol. The flower buds are eaten with betel leaves as a febrifuge. The leaves yield 5.6 per cent pectin having low-jellying quality [Naves & Mazuyer, 231; Watson *et al.*, loc. cit.; Menon & Menon, *Curr. Sci.*, 1957, **26,** 89; *Chem. Abstr.*, 1930, **24,** 4585; Maruzzella *et al.*, *Amer. Perfum.*, 1959, **74**(2), 21; Pankajamani & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 93; Dymock, Warden & Hooper, II, 421; Scharpenseel & Vicario, *Araneta J. Agric.*, 1956, **3**(4), 57].

Many parts of the plant are considered medicinal. The bark has a stimulant action. A decoction of it is used as a purgative, emmenagogue and febrifuge. It is also given for dropsical and venereal affections and is reported to be a powerful antiherpetic. The bark yields a bitter glucoside plumieride ($C_{21}H_{26}O_{12}$, m.p. 224–25°, yield 4%), a pigment fulvoplumierin (5′-carbomethoxy-3′,4′-1,2-cumalino-ω-propenylfulvene, $C_{14}H_{12}O_4$, m.p. 151–52° decomp.), and α-amyrin acetate. Fulvoplumierin inhibits the growth of various strains of *Mycobacterium tuberculosis*. The extract of the bark shows antifungal activity against *Helminthosporium sativum* (Jamwal & Anand, *Indian J. Pharm.*, 1962, **24,** 218; Burkill, II, 1777–78; Brown, 1946, III, 247; Kirt. & Basu, II, 1563; Schmid *et al.*, *Helv. chim. acta*, 1952, **35,** 415; Halpern & Schmid, ibid., 1958, **41,** 1109; Schmid & Bencze, ibid., 1953, **36,** 205, 1468; Grumbach *et al.*, *Experientia*, 1952, **8,** 224; Rangaswami *et al.*, *Indian J. Pharm.*, 1961, **23,** 122; Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49,** 799).

The latex of the plant has rubefacient and purgative properties. It enters into applications for itch, rheumatism, and gum troubles. Excessive doses are poisonous. The latex contains calcium salts of

plumieric acid, cerotic acid and acetyl lupeol. On analysis, the coagulums of latex samples taken from trees in Coorg and Palghat showed respectively: caoutchouc, 19.1, 16.1; resins, 62.7, 75.6; and insolubles, 18.2, 8.4% (Kirt. & Basu, II, 1562; Burkill, II, 1777–78; Chopra *et al.*, I, 557; Wehmer, II, 981; Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 4).

The root is a violent cathartic. The plant is reported to be toxic to animals [Chopra, 1958, 569; Mishra & Patra, *Indian Live-Stk*, 1963, **1**(3), 12].

The wood is yellowish white and soft (wt., 592–673 kg./cu.m.) and is reported to be free from attack by termites. It is used for making drums and other musical instruments (Gamble 483; Talbot, II, 215; Rama Rao, 253).

P. alba Linn. WHITE CHAMPA

Blatter *et al.*, 118.

TEL.—*Veyvi varahaalu;* TAM.—*Perumal arali, seemai arali;* MAL.—*Vella champakam.*

A small tree, 4.5 m. high, occasionally grown in the gardens. Leaves lanceolate to oblanceolate; flowers white, fragrant, in corymbose fascicles. It remains in leaf for most part of the year.

The fruit is edible. The latex is applied to ulcers, herpes and scabies, and the seeds are said to possess haemostatic properties. Other medicinal uses are almost the same as those of *P. acuminata*. The latex gave: moisture, 71.14; total solids, 28.86; alcohol extr., 9.62; chloroform extr., 1.53; and residue, 17.54%. The bark contains α- and β-amyrins and their acetates, plumieride, scopoletin, and β-sitosterol (Watt & Breyer-Brandwijk, 94; Kirt. & Basu, II, 1564; Viswa Nath, *J. sci. industr. Res.*, 1942–43, **1**, 373; Rangaswami & Venkata Rao, *Proc. Indian Acad. Sci.*, 1960, **52A**, 173).

P. rubra Linn.

Blatter *et al.*, 117, Pl. XXIV.

MAR.—*Lal champa;* TAM.—*Segappu arali.*

DELHI—*Champa;* SANTAL—*Lal golainchi.*

A small tree, 3.5–6.0 m. high, commonly grown in the gardens. Leaves lanceolate to obovate-oblong; flowers very fragrant, generally red, pink or purple centred with rich yellow.

The fruit is reported to be eaten in West Indies. In India, however, it has been used as an abortifacient. Medicinal properties of this plant are more or less similar to those of *P. acuminata* (Watt & Breyer-Brandwijk, 94).

The flowers are used in pectoral syrups. They contain resin, quercetin, traces of kaempferol and a cyanidin diglycoside. The fresh leaves and bark contain respectively: plumieride, 0.83, 0.53; and resinic acid, 1.26, 0.4%. A recent examination of the bark showed the presence of fulvoplumierin, a mixture of terpenoids and sterols and large quantities of plumieride. The latex coagulum from the young branches on analysis gave: caoutchouc, 25.5; resinous matter, 21.9; and moisture, 15.7% (Kirt. & Basu, II, 1564; Wehmer, II, 982; Pankajamani & Seshadri, *J. sci. industr. Res.*, 1955, **14B**, 93; Ponniah & Seshadri, ibid., 1953, **12B**, 605; Venkata Rao & Anjaneyulu, *Indian J. Pharm.*, 1966, **28**, 80).

POA Linn. (*Gramineae*)

A large genus of grasses distributed in the temperate or mountainous regions of both hemispheres. About 49 species have been recorded from India, many of them valued as useful pasture grasses.

P. annua Linn. DWARF OR ANNUAL MEADOW GRASS

D.E.P., VI(1), 249; Fl. Br. Ind., VII, 345; Bor, 1960, 555; Fyson, I, 679, Pl. 609.

PUNJAB—*Chirua.*

A tufted, glabrous, prostrate or sub-erect grass found throughout the temperate and sub-alpine Himalayas, in Kashmir, in North India up to 2,700 m., and in the Khasi and Nilgiri hills. Stems 15–30 cm.; leaves linear, flat, flaccid; panicles ovate or lax up to 8 cm. long; spikelets 4–6 mm. × 2 mm., oblong, ovate, usually green.

FIG. 58—POA ANNUA

P. annua is reported to have its origin in some form or forms which originated by hybridization of *P. infirma* H.B. & K. and *P. supina* Schrad. *P. annua* exhibits morphological characters intermediate between them. Both the parental types are found in the mountains of Central Asia; however, according to some, northern Mediterranean is also considered as its place of origin. Several of the more widespread species such as *P. pratensis* have developed numerous ecotypes which enable the species to occupy different habitats (Chrtek & Jirasek, *Preslia,* 1962, **34,** 40; Bor, *J. Bombay nat. Hist. Soc.,* 1951–52, **50,** 824; Tutin, *Watsonia,* 1957–61, **4,** 1; Hartley, *Aust. J. Bot.,* 1961, **9,** 152).

This is a very variable plant, some races of which are annual, while others are sub-perennial.

The grass forms a bright green, handsome turf on the ground by its dense growth, but withers in the summer heat. It is considered suitable for cultivation in Delhi during cold season. It is said to be very nutritious although the yield is rather poor (Fl. Delhi, 407; Bor, *J. Bombay nat. Hist. Soc.,* 1951–52, **50,** 787; Hubbard, 145).

In Jammu and Kashmir, the grass is found abundantly and is used as a fodder, both in the green and dry state. It contains (dry basis): protein, 11.01–14.74; ether extr., 2.77–3.26; crude fibre, 26.33–33.0; carbohydrates, 33.99–46.23; mineral matter, 8.76–16.06; calcium (CaO), 0.44–1.27; and phosphorus (P_2O_5), 0.39–0.78% (Chopra *et al., Indian J. agric. Sci.,* 1956, **26,** 415).

P. bulbosa Linn. var. **elanata** Stapf BULBOUS MEADOW GRASS

D.E.P., III, 437; Fl. Br. Ind., VII, 338; Bor, 1960, 556.

A densely tufted grass, bulbous at the base found in the western Himalayas at altitudes of 1,500–2,700 m. Stems 15–40 cm., terete, smooth; leaves linear, acute, flat; panicle oblong, 2.5–5.0 cm., spikelets 5 6 mm.

The leaves and culms wither early leaving the bulbous bases. These contain food reserves and may become detached and blown about by wind, each forming the basis of a new plant (Hubbard, 147).

The grass is useful as fodder. Analysis of the grass from Srinagar gave the following values (dry basis): protein, 8.36; ether extr., 3.15; crude fibre, 26.85; carbohydrates, 52.99; mineral matter, 7.42; calcium (CaO), 0.62; and phosphorus (P_2O_5), 0.61% (Chopra *et al., Indian J. agric. Sci.,* 1956, **26,** 415).

P. compressa Linn. FLATTENED MEADOW GRASS, CANADA BLUE GRASS

D.E.P., III, 437; Bor, 1960, 556; Hitchcock, 106, Fig. 120.

A stiff, wiry, perennial grass found in the temperate parts of Europe, and rarely in India. Culms short, strongly flattened, generally 15–20 cm., or rarely 70 cm. in height; leaf blades short, 1–4 mm. wide.

The grass is used as a fodder. In America, it is valued as pasture, especially on thin, poor soils and stiff clays. It spreads by rhizomes and forms a close turf. It is grazed upon by all herbivorous animals and withstands close grazing. It is considered excellent for fattening cattle (Whyte *et al.,* 1959, 364; Piper, 185).

Analysis of the green grass gave the following values: moisture, 66.8; protein, 3.0; fat, 1.2; carbohydrates, 6.1; fibre, 10.3; ash, 2.6; calcium, 0.4; phosphorus, 0.1; potassium, 0.5; dig. protein, 1.9; and total dig. nutrients, 19.9%; nutritive ratio, 9.5. Hay made from the grass has the following nutritive values: protein, 6.6; dig. protein, 2.8; carbohydrates, 46.4; and total dig. nutrients, 53.3%; nutritive ratio, 18.0 (Morrison, 375, 1020, 1002).

P. nepalensis Wall. ex Duthie syn. *P. annua* var. *nepalensis* Griseb.

Fl. Br. Ind., VII, 345; Bor, *J. Bombay nat. Hist. Soc.,* 1951–52, **50,** 787; Bor, 1960, 558.

A tall, perennial grass with a creeping rootstock found in Kumaun, Tehri-Garhwal and Kulu. Stem 50 cm.; leaves 30–50 cm.; panicle up to 15 cm.; spikelets whitish in colour, 3.5–4.0 mm. long.

The grass is useful as fodder. It contains (dry basis): protein, 14.97; ether extr., 3.18; carbohydrates, 36.90; crude fibre, 29.63; mineral matter, 13.67; calcium (CaO), 0.67; and phosphorus (P_2O_5), 0.97% (Chopra *et al., Indian J. agric. Sci.,* 1956, **26,** 415).

P. pratensis Linn. SMOOTH-STALKED MEADOW GRASS, KENTUCKY BLUE GRASS

D.E.P., VI(1), 297; Fl. Br. Ind., VII, 339; Bor, *J. Bombay nat. Hist. Soc.,* 1952–53, **51,** 61.

A perennial, stoloniferous grass, found within the temperate and alpine zones of the Himalayan range, and in the temperate regions of Europe and America. Stems 15–30 cm., smooth, terete; leaves crowded at the base of the stem, linear, firm or flaccid; panicle ovate or oblong; spikelets ovate acute, crowded, green, 4–5 mm.

This species includes a large number of races and strains. It has been introduced in the temperate hills

of India, where it does well and grows wild in many places. It is an excellent pasture and lawn grass, rich in protein when young and relished by all classes of stock. The grass in bloom stage or later is poorer in protein and high in fibre. Analysis of the green grass from Jammu and Kashmir gave the following ranges of values (dry basis): protein, 7.73–12.54; ether extr., 1.63–3.22; carbohydrates, 39.02–49.38; fibre, 30.58–37.85; and ash, 8.0–12.8%. The average mineral composition of the grass is as follows: calcium, 0.16; phosphorus, 0.13; potassium, 0.59; sodium, 0.07; sulphur, 0.20; magnesium, 0.07; and iron, 0.006%; manganese (2.4 mg./100 g.), copper (0.42 mg./100 g.) and iodine (750 μg./100 g.) are also present. The vitamins present in the grass are: carotene (as vitamin A), 7.93; thiamine, 0.26; and α-tocopherol, 15.6 mg./100 g. The grass also contains pectic substances (6.5%, as calcium pectate, dry basis) and probably a cyanogenetic glycoside (Hubbard, 165; Bor, 1960, 559; Morrison, 365–66, 1020, 1097, 1106, 1113; Chopra *et al., Indian J. agric. Sci.*, 1956, **26**, 415; Iodine Content of Foods, 105; Kertesz, 306; Wehmer, I, 80).

The grass can be made into hay. The product from grass cut in early bloom is nearly equal to timothy in feeding value. Analysis of the hay gave the following values: protein, 8.2; dig. protein, 4.8; and total dig. nutrients, 54.8%; nutritive ratio, 10.4. The grass can also be ensiled (Morrison, 366, 1002, 1036).

P. songarica Boiss. = *Eremopoa persica* (Trin.) Roschev. var. *songarica* Bor syn. *Poa persica* Trin. var. *songarica* Hook. f.

D.E.P., III, 437; Fl. Br. Ind., VII, 337; Bor, 1960, 532.

A slender, erect, quite glabrous, usually flaccid annual, up to 45 cm. high, found in the western Himalayas from Kunawar to Kashmir and western Tibet, at 2,100–3,600 m. altitude. Leaves narrowly linear, flat; inflorescence a panicle; spikelets green.

This grass is often gregarious, covering considerable areas at high altitudes. Analysis of the grass gave the following values (dry basis): protein, 6.19; ether extr., 2.08; crude fibre, 35.71; carbohydrates, 49.12; mineral matter, 6.24; calcium (CaO), 0.28; and phosphorus (P_2O_5), 0.39% (Bor, 1960, 532; Chopra *et al., Indian J. agric. Sci.*, 1956, **26**, 415).

P. trivialis Linn. ROUGH MEADOW GRASS

D.E.P., VI(1), 297; Fl. Assam, V, 70; Bor, *J. Bombay nat. Hist. Soc.*, 1952–53, **51**, 61.

A glabrous, perennial, loosely tufted grass found in Lahul and introduced and grown in the cooler regions in Assam, Nilgiris and Palnis. Culms up to 60 cm. tall, geniculate below; leaves linear-acute, 6.25 cm. by 2.5–6.5 mm., flat and flaccid; inflorescence obovate to oblong; spikelets green or purplish, ovate to oblong, 1.25–5.0 mm. long.

It is an excellent grass for shady lawns, and may be utilized as a pasture for moist lands. In stiff, moist lands, it yields an abundant and excellent fodder, but is affected by drought. It is also suitable for making hay (Piper, 188; Bor, 1960, 561).

P. alpina Linn. (ALPINE MEADOW GRASS), a densely tufted, usually low, often gregarious grass found in the western Himalayas from Kashmir to Garhwal up to a height of 4,800 m., is useful as fodder (Bor, 1960, 555).

P. nemoralis Linn. (WOOD MEADOW GRASS), a very variable, shade-loving grass, with an erect, rigid stem, cauline leaves and lax panicle, is found in the temperate and alpine Himalayas at medium and high altitudes. Sometimes it is found growing on shady rock faces where there is sufficient moisture. It is used as fodder and also for shady lawns (Piper, 188; Hubbard, 153; Stewart, *Brittonia, N.Y.*, 1945, **5**, 419; Bor, 1960, 558).

P. pagophila Bor syn. *P. flexuosa* Hook. f. (Fl. Br. Ind.), non Wahlb.; *P. cenisia* All. ex Duthie forms a large part of the vegetation on the alpine slopes of the Himalayas, mainly in Kumaun and Sikkim. It forms a considerable part of the grazing grass for sheep and ponies (Bor, 1960, 558).

P. palustris Linn., though not common in India, is widespread in the temperate regions of the northern hemisphere. It has been probably introduced into Kashmir. It is a reputed fodder grass in North America (Bor, 1960, 559).

P. sikkimensis Bor syn. *P. annua* var. *sikkimensis* Stapf, an annual or sub-perennial grass, with culms up to 30 cm. high, flat, linear blades and pyramidal panicle, is found in Sikkim, up to an altitude of 3,000–4,000 m. It may be used as fodder (Bor, 1960, 560).

Besides these, the following species of *Poa* which are generally found in the alpine Himalayas from Kashmir to Bhutan, in Sikkim and in Tibet are also reported to be good as fodder grasses: *P. himalayana* Nees ex Steud.; *P. khasiana* Stapf; *P. tibetica* Munro ex Stapf; *P. poophagorum* Bor; and *P. sterilis* Bieb. (Bor, 1960, 557).

PODOCARPUS L'Herit. ex Pers. (*Taxaceae; Podocarpaceae*)

A large genus of evergreen, mostly dioecious trees and shrubs, largely confined to the forests of the subtropical and warm temperate regions of the southern hemisphere. Several species yield valuable timbers (Yellow-woods), used more or less for the same purpose as the pine woods. Some species are grown for ornament. Two species occur wild in India and a few exotics have been introduced.

P. neriifolius D. Don; Hook. f. (Fl. Br. Ind.) in part THITMIN, MOUNTEAK

D.E.P., VI(1), 298; Fl. Br. Ind., V, 649; Raizada & Sahni, *Indian For. Rec., N.S., Bot.*, 1960, **5**, 105.

HINDI—*Halis.*

ASSAM—*Kat-bhaluka;* CACHAR—*Jinari;* KHASI—*Dieng-sia-blei;* LUSHAI—*Kherewal-tak, thlang-phar;* LEPCHA—*Dung kung;* NEPAL—*Gunsi;* ANDAMANS— *Thitmin, welimada.*

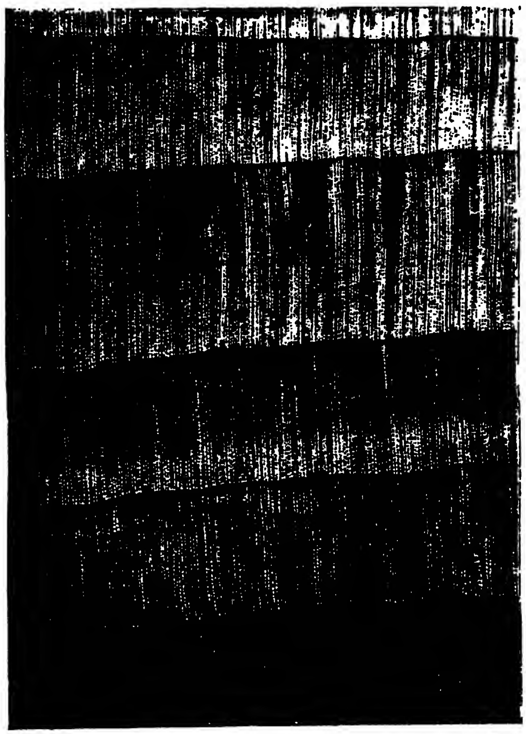
TRADE—*Thitmin.*

A graceful tree with whorled branches, up to 40 m. tall, but very variable in size, met with in the evergreen forests of the outer hills of the eastern Himalayas and in the hills of Assam, ascending to an altitude of about 1,500 m.; it is also found in the Andamans. Bark greyish brown, fibrous; leaves scattered or indistinctly whorled, linear-lanceolate, 10–18 cm.×8–15 mm. on old trees and 13–25 cm.×13–19 mm. on young trees, coriaceous; male and female flowers axillary; seeds globose or obovate, 6–8 mm. in diam., borne on a fleshy, oblong, deep purple receptacle. Some authors have raised var. *brevifolius* Stapf, with smaller leaves, to the specific rank (Gray, *J. Arnold Arbor.*, 1958, **39**, 460, 441).

Generally, the trees in the Himalayas and Assam hills attain a height up to 18 m. and a girth up to about 2 m., although a girth of 3.8 m. has also been recorded. The trees occurring in the high hills of the Middle Andamans remain stunted, but elsewhere they attain larger dimensions and yield useful timber (Pearson & Brown, II, 1028; Bhadran, *Indian For.*, 1958, **84**, 326).

The tree deserves large scale cultivation, as it yields a high class timber, used for general carpentry work. It is propagated through seeds, which retain their viability for more than a year. The seedlings are raised in nurseries at the beginning of the monsoon period. The beds are provided with shade and are irrigated if the rainfall is inadequate. The seeds germinate within a fortnight; the germination percentage is about 65, survival rate being almost equal. If the seedlings are transplanted under heavy shade, 70 per cent of them survive. The rate of growth of the tree is, however, slow, average annual girth increment being about 1 cm. (Ganapathy, *Indian For.*, 1965, **91**, 761; Gamble, 703).

The wood is straw-yellow to greyish yellow, straight-grained, medium coarse- but even-textured, soft to moderately hard, and light (sp. gr., 0.48–0.55; wt., 545–801 kg./cu.m.). It seasons well with care and does not warp, twist or develop surface cracks. When thoroughly seasoned, it does not tend to expand or contract with varying conditions of humidity. The logs are converted when green and open stacked under cover. The wood is durable under cover and in contact with water, but is, perhaps, not resistant to white ants. Graveyard tests have shown a durability of 5–7 years. The wood does not lend itself to treatment easily, but its treatability can be improved for small-sized pieces, not exceeding 6 cm. in thickness, under pressure-treatment. It saws with great ease, and is said to be one of the finest timbers to work upon, though it finishes to a somewhat dull surface.



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 59—PODOCARPUS NERIIFOLIUS—TRANSVERSE SECTION OF WOOD (×10)

The data for comparative suitability of the timber, expressed as percentage of the same properties of teak, are: wt., 80; strength as a beam, 75; stiffness as a beam, 85; suitability as a post, 80; shock-resisting ability, 65; retention of shape, 75; shear, 80; and hardness, 70 (Pearson & Brown, II, 1029–30; Gamble, 703; Purushotham *et al., Indian For.*, 1953, **79,** 49; Masani, ibid., 1964, **90,** 229; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 57, Sheet No. 16).

The timber is used for making oars, paddles, boat-hooks, spars and masts. It is suitable for camp furniture, ladders, aeroplane parts, mathematical instruments, pen-holders, and tea-boxes, and is also useful for planking. The wood is rather tough for pencils, but a process to make it suitable for pencil manufacture has been developed in East Pakistan. It has been reported that the pencils made from the treated wood are of high quality and may be substituted for cedar pencils. It is a poor quality fuel-wood: calorific value, 4,302 cal., 7,744 B.t.u. (Pearson & Brown, II, 1030; Trotter, 1944, 197; Parkinson, 257; Gamble, 703; Rodger, 59; Khan, *Pakist. J. For.*, 1963, **4,** 367; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

The fleshy receptacles of the fruit are eaten in Nepal; they weigh about 580 to a kg. (Uphof, 288; Ganapathy, loc. cit.).

P. wallichianus Presl syn. *P. latifolia* Wall. non R. Br. (TAM.—*Narambali*; KAN.—*Kurunthumbi*; KHASI—*Soplong*; LUSHAI—*Thing-romao*) is a tall, evergreen tree with a dense foliage, up to 24 m. or more in height and 2 m. in girth, found in the hills of Assam, Madras and Kerala at altitudes of 900–1,500 m.; it has also been recorded from the Nicobars. The tree is sometimes grown in gardens for ornament. The wood is grey, slightly aromatic, even-grained, moderately hard and light (sp. gr., 0.49; wt., 513–529 kg./cu.m.). Graveyard tests have shown a durability of 2–5 years. The timber is utilized more or less for the same purposes as that of *P. neriifolius* (Gamble, 702; Rodger, 149; Purushotham *et al., Indian For.*, 1953, **79,** 49).

Amongst the species introduced into India for trial purposes, *P. elongatus* L' Herit., *P. falcatus* R. Br. ex Mirb. (OTENIQUA YELLOW-WOOD), and *P. gracilior* Pilger (MUSENGERA), natives of Africa, and *P. montanus* Lodd. syn. *P. montanus* var. *diversifolius* Dallimore & Jackson, *P. taxifolia* Kunth (PINO), a native of South America, are worthy of mention due to their timber value in their native countries. Of these, *P. gracilior,* a medium-sized tree, has been doing well in the Forest Research Institute, Dehra Dun, for over forty years, and *P. montanus,* a small tree, has established itself in the Nilgiris. The wood of *P. gracilior* is found suitable for doors, flooring, panelling, and furniture, taking nails better than most of the yellow-woods. The wood of *P. montanus* is used for cabinet-work. *P. macrophyllus* D. Don (KUSAMAKI), a native of China and Japan, is an ornamental tree grown in gardens for its graceful, dense, dark green foliage. *P. macrophyllus* var. *maki* Sieb. syn. *P. chinensis* Wall. stands clipping well and is planted for hedges in Japan (Krishnamurthi, 222; Mukherji & Thapar, *Indian For.*, 1961, **87,** 484; Raizada & Hingorani, 34; Handbook of Empire Timbers, 114, 138; Dallimore & Jackson, 67, 70, 76; Streets, 617; Benthall, 480).

PODOPHYLLUM Linn. (*Berberidaceae*)

A small genus of herbs distributed in the north temperate regions. Three species are reported from the Himalayan region of India of which *P. hexandrum* constitutes the source of an important pharmacopoeal drug (Indian Podophyllum).

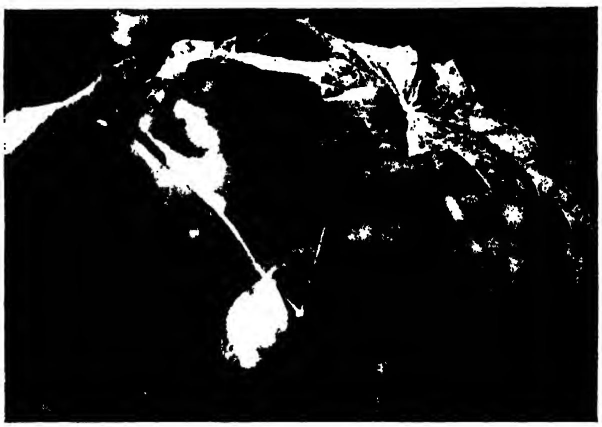
P. hexandrum Royle syn. *P. emodi* Wall. ex Hook. f. & Thoms. INDIAN PODOPHYLLUM

D.E.P., VI(1), 299; C.P., 904; Fl. Br. Ind., I, 112; Nakao, 142, Fig. 187 & 188.

HINDI—*Bakrachimaka, bhavanbakra, papra, papri*; BENG.—*Papra*; MAR.—*Padwel, patvel*; GUJ.—*Venivel*.

PUNJAB—*Bankakri, papri*; KASHMIR—*Banwangan*.

An erect, glabrous, succulent herb, 35–60 cm. high, with creeping, perennial rhizome, bearing numerous roots found in the inner range of the Himalayas



Bot. Surv. India. Photo: M. A. Rau

FIG. 60—PODOPHYLLUM HEXANDRUM—FRUITING BRANCH

from Kashmir to Sikkim, at altitudes of 3,000–4,200 m. Leaves 2 or 3, orbicular-reniform, palmate, peltate, with lobed segments; flowers solitary, white or pink, cup-shaped; fruit an oblong or elliptic berry, 2.5–5.0 cm. diam., orange or red, containing many seeds embedded in the pulp.

This species exhibits a certain amount of variation in its botanical features. Specimens collected mostly from the eastern Himalayas differ from those of the north-western Himalayas, particularly in the nature of leaf-insertion. They have been classified into three or four varieties, viz. var. *hexandrum*, var. *axillaris*, var. *bhootanensis* and var. *jaeschkei* [Chatterjee, *Rec. bot. Surv. India*, 1953, **16**(2), 44; *Econ. Bot.*, 1952, **6**, 342].

The plant flourishes well as an undergrowth in the fir forests, rich in humus and decayed organic matter. It is generally associated with species of *Rhododendron, Salix, Juniperus* and *Viburnum*, but is also met with in open alpine meadows, where its occurrence is less frequent. The plant loves moist and shady localities situated between 2,500 and 4,000 m. (Chatterjee, *Econ. Bot.*, 1952, **6**, 342; Kapoor & Sarin, *Bull. reg. Res. Lab., Jammu*, 1962, **1**, 38).

The rhizomes and roots of the plant, which constitute the drug, are obtained entirely from wild plants growing throughout the Himalayas, especially from the Central Himalayas where they grow luxuriantly in open meadows at elevations of 3,000–3,500 m. The underground rhizomes remain dormant during winter and produce aerial shoots in April or May, depending upon the melting of snow at different altitudes and aspects. The shoots bear flower and fruit during summer and die down in November. Rhizomes which bear 3–5 aerial shoots are considered suitable for collection. The rhizomes and roots are dug up in spring or autumn, cleaned, dried in the sun, sifted, packed and stored in gunny bags; sometimes they are cut into cylindrical pieces and carefully dried. It is stated that rhizomes gathered in spring contain a higher resin content than those obtained in autumn. Freshly collected rhizomes are reported to contain larger quantities of active principles which are lost on prolonged storing [Chatterjee, *Econ. Bot.*, 1952, **6**, 342; Chopra, 1958, 288; Kapoor & Sarin, loc. cit.; Information from Messrs Sandoz (India) Ltd.].

In view of the inaccessible areas from where the drug is obtained and the continuing demand for it both in India and abroad, attempts have been made from time to time to cultivate the plants, either from seeds or from rhizome cuttings. Seeds under natural conditions have been found to germinate after remaining dormant for one or two years, and if sown without the pulp, even failed to germinate. Preliminary treatments like soaking them in water or treating with sulphuric acid had no effect. Seeds sown with the pulp in June or July immediately after collection also remained dormant for 9–10 months and showed germination only in the following spring, after the melting of snow. Seeds sown in boxes in Dehra Dun, however, showed germination in 3–7 months. Seedlings so raised took a number of years to produce fair-sized, marketable rhizomes. Propagation by rhizome cuttings, 1.0–2.5 cm. in length, has also been tried. It has been found that the youngest top portions of the rhizome, bearing leafy buds gave the best results. Their growth, however, was slow and took 4–6 years to produce rhizomes suitable for exploitation (Troup, *Indian For.*, 1915, **41**, 361; Badhwar & Sharma, ibid., 1963, **89**, 445; Chopra, 1958, 228; Chatterjee, loc. cit.; Jagjit Singh, *Indian For.*, 1964, **90**, 500; Krishnamurthy *et al.*, ibid., 1965, **91**, 470).

Utilization and Composition—Rhizome is irregular, tortuous, knotty, about 2–5 cm. long and 1–2 cm. thick, somewhat flattened dorsiventrally; upper surface is characterized by the presence of 3 or 4 cup-shaped scars; colour is externally yellowish brown to earthy brown. Surface, when transversely cut, appears smooth and is irregularly circular in outline. Odour is slight and characteristic; taste is somewhat bitter and acrid; powder intensely irritating to the eyes. Roots are adventitious and arise mainly from the enlarged portion of the rhizome and attain a length of about 7 cm. and a thickness of 2.5 mm. Fracture of both rhizome and root is weak, brittle and even. Odour of root is slight; taste is disagreeably bitter and acrid (I.P., 488; Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 30).

The dried rhizomes and roots of *P. hexandrum* (Indian Podophyllum) are official in I.P. and form the source of a medicinal resin. Official podophyllum contains not less than 8 per cent resin, and is utilized almost entirely for the preparation of Podophyllum Resin or Podophyllin, commonly used as a purgative. The resin content of the roots and rhizomes varies with locality and the season of collection, and on an average ranges from 7 to 15 per cent. Drying of the rhizome in the sun does not appear to affect the resin content. Rhizome collected in May has a higher resin content than that collected in November: the older rhizomes, however, yield a resin richer in podophyllotoxin. According to B.P.C., the roots form a large

proportion of the Indian drug and are mainly detached from the rhizome. The roots are richer in resin than the rhizomes and it has been recommended that the roots should be gathered in May when the plant is in flower. The leaves yield 7.8–9.7 per cent of resin and it has been suggested that they should form the main source of this drug in view of the slow growth of the rhizomes and roots, the rapid depletion of the natural growth and absence of any active regeneration (I.P., 488; B.P.C., 1963, 635; Puran Singh, *Indian For. Bull., N.S.*, No. 9, 1912; Hussain *et al., J. Pharm., Lond.*, 1954, **6**, 62; U.S.D., 1955, 1081).

In recent years, the resin podophyllin and its active principle, podophyllotoxin, have received considerable attention for their tumour necrotizing properties. Podophyllin is listed in various pharmacopoeias and formularies. B.P. recognizes the dried roots and rhizomes of both *P. hexandrum* and the American plant *P. peltatum* Linn. as the sources of the resin, podophyllin. The resin is extracted from the rhizome by precipitation of its alcoholic extract with slightly acidulated water. The American Podophyllum has a lower content of resin (2–8%) and its resin contains about half the amount of podophyllotoxin as that of the Indian podophyllum; the active principles, α- and β-peltatins, isolated from the former are, however, absent in *P. hexandrum*. Podophyllins from the two sources are stated to differ little in their physiological activity (B.P., 1963, 625; U.S.D., 1955, 1078).

Podophyllin is an amorphous powder varying in colour from light brown to greenish yellow or brownish grey, with a characteristic odour and bitter and acrid taste. On exposure to light or to temperature above 25°, it becomes darker in colour. B.P. requirements for podophyllin are: alcohol (95%)-insol. matter, $\not>$25 mg./g.; dil. ammonia-insol. matter, $\not<$180 and $\not>$250 mg./0.5 g. in *P. hexandrum* resin, and $\not>$50 mg./0.5 g. in *P. peltatum* resin; loss on drying, $\not>$5.0%; and sulphated ash, $\not>$1.0%. According to I.P., podophyllin (from *P. hexandrum*) contains not less than 40 and not more than 50 per cent podophyllotoxin (B.P., 1963, 625; U.S.D., 1955, 1079; I.P., 487).

The resins from *P. peltatum* and *P. hexandrum* can be distinguished by treating their alcoholic solutions with aqueous potassium hydroxide, when the resin of the former does not gelatinize but that of the latter produces a stiff jelly. Another distinction is that a few drops of a strong solution of copper acetate produce a bright green colouration with the alcoholic extract of the resin from American podophyllum and a brown precipitate with that from Indian podophyllum (B.P., 1963, 625; Denston, 283).

Podophyllin from *P. hexandrum* contains podophyllotoxin as the major active constituent, in amounts ranging from 32 to 54 per cent; a number of other related compounds and their glucosides have been isolated from the resin (Table 1). It also contains quercetin (8%), kaempferol, astragalin (kaempferol-3-glucoside), an essential oil (3.7%) responsible for the odour of podophyllin, wax (8.6%) and mineral salts. Podophyllotoxin is a lignan compound (a substance whose structure is based on 2,3-dibenzylbutane) with a labile lactone ring and a *trans* (1:2)-*trans* (2:3)-*cis* (3:4) configuration. Several polymorphic modifications and solvates of podophyllotoxin, with varying melting points, have been obtained. In alkaline solution, it is readily converted to its C_3 epimer, picropodophyllin; the related compounds of the toxin series likewise epimerize with alkalies to the

TABLE 1—LIGNAN COMPOUNDS OF PODOPHYLLIN FROM P. HEXANDRUM

	Mol. formula	m.p.
Podophyllotoxin[1]	$C_{22}H_{22}O_8$	a[a]
Podophyllotoxin-β-D-glucoside[3]	$C_{28}H_{32}O_{13}$	149–52°
Picropodophyllin[1,b]	$C_{22}H_{22}O_8$	235–36°/252–54°
1-O-(β-D-glucopyranosyl)-picropodophyllin[4]	$C_{28}H_{32}O_{13}$	237–38°
4′-Demethylpodophyllotoxin[4]	$C_{21}H_{20}O_8$	250–52°
4′-Demethylpodophyllotoxin β-D-glucoside[3]	$C_{27}H_{30}O_{13}$	165–67°
Dehydropodophyllotoxin[5,6]	$C_{20}H_{18}O_8$	272–74°
Podophyllol (podophylloresin)[1]	$C_{20}H_{22}O_8 \cdot H_2O$	115° decomp.
Podophyllic acid[1,b]	$C_{22}H_{24}O_9$	163–65° decomp.
4′-Demethyldeoxypodophyllotoxin β-D-glucoside[7]	$C_{27}H_{30}O_{12}$	146–58°

[1] Kelly & Hartwell, *J. nat. Cancer Inst.*, 1953–54, **14**, 967; [2] Schrecker *et al., J. org. Chem.*, 1956, **21**, 288; [3] Stoll *et al., J. Amer. chem. Soc.*, 1954, **76**, 3103, 5004; [4] Nadkarni *et al.*, ibid., 1953, **75**, 1308; [5] *Chem. Abstr.*, 1959, **53**, 22477; [6] Wartburg *et al., Helv. chim. acta*, 1957, **40**, 1331; [7] Wartburg *et al.*, ibid., 1964, **47**, 1203.

[a] 183–84°, 188–89° (polymorphic unsolvated forms); 161–62° (with water of crystallization); 114–18° (with water and benzene of crystallization).

[b] The compound is an artefact and does not occur naturally in podophyllin.

corresponding members of the picro series. Picropodophyllin hydrolyses with sodium hydroxide to podophyllic acid, which in turn is lactonized exclusively to the original picropodophyllin; both these compounds do not occur as such in podophyllin, and are the alkali conversion products of podophyllotoxin. Podophyllol is believed to consist essentially of a lignan related to podophyllotoxin. α- and β-Peltatins ($C_{21}H_{20}O_8$, m.p. 231–33°, and $C_{22}H_{22}O_8$, m.p. 231–38°, respectively), isolated from *P. peltatum* bear the same structural relationship to each other as demethylpodophyllotoxin and dehydropodophyllotoxin [Kelly & Hartwell, *J. nat. Cancer Inst.*, 1953–54, **14,** 967; Chakravarti & Chakraborty, *J. Amer. pharm. Ass., sci. Edn*, 1954, **43,** 614; *Chem. Abstr.*, 1955, **49,** 9106; Nadkarni *et al.*, *J. Amer. chem. Soc.*, 1953, **75,** 1308; Hartwell & Schrecker, ibid., 1951, **73,** 2909; Wartburg & Kuhn, *Experientia*, 1965, **21**(2), 67; Pankajamani & Seshadri, *Proc. Indian Acad. Sci.*, 1952, **36A,** 157; Schrecker *et al.*, *J. org. Chem.*, 1956, **21,** 288; Wartburg *et al.*, *Helv. chim. acta*, 1957, **40,** 1331].

Podophyllin is considered a cholagogue, purgative, alterative, emetic and a bitter tonic. It is a drastic but slowly acting purgative producing copious watery stools; it may cause much griping, and is therefore given in conjunction with belladonna and hyoscyamus. It can also be used like colchicine, in cytological work because it affects spindle formation and disperses chromosomes. Owing to its cytotoxic action it is used as a paint in the treatment of soft venereal and other warts. Podophyllin is a toxic material and is strongly irritant to skin and mucous membranes. In large doses, it causes severe vomiting, diarrhoea and may result in death; exposure to its dust may cause similar symptoms. Podophyllin is also used in veterinary medicine as a cathartic for dogs and cats. Its action on horses and cattle is variable and frequently ineffective. An ointment of podophyllin is employed to remove warts in animals; care is taken that it is not licked off by the animal and does not come in contact with the eyes (I.P.C., 208; Nadkarni, I, 994; Sullivan & Wechsler, *Science*, 1947, **105,** 433; B.P.C., 1963, 637; Chopra *et al.*, I, 140; U.S.D., 1955, 1079, 2009; B.V.C., 288).

Podophyllin and its active principles stimulate peristalsis of the isolated small intestines and of the colon of the guinea-pig, depress the isolated duodenum of rat, but cause contractions of the isolated ileum of guinea-pig; like many other purgatives, the drug combines with serum albumin. The cardiovascular effects of sub-lethal doses of podophyllin are reported to be relatively mild and transitory. At lethal doses, a failing respiration and muscular dystrophy were accompanied by a fall in blood pressure to shock levels. Interruption of pregnancy was produced in mice and rabbits by intravenous, subcutaneous, or oral administration of non-lethal doses of podophyllotoxin. The toxin completely inhibits the larval development of houseflies, the lowest effective concentration being 0.12 per cent by weight (Kelly & Hartwell, loc. cit.; *Chem. Abstr.*, 1958, **52,** 20653; Wiesner & Yudkin, *Nature, Lond.*, 1955, **176,** 249; Konecky & Mitlin, *J. econ. Ent.*, 1955, **48,** 219).

Podophyllin has been tried in the treatment of a number of diseases, particularly those characterized by warty lesions of the skin and neoplasms occurring in the regions of the body accessible to topical therapy. It is considered the drug of choice in the treatment of condyloma acuminatum because of its effectiveness, the simplicity of treatment and the absence of severe pain to the patient. Podophyllin has been tried in tinea capitis with equivocal results. It has been described as an effective vermifuge, first stimulating, then paralysing and finally killing *Ascaris*. It has given symptomatic relief in some of the allergic and inflammatory conditions of the skin. Papilloma of various sites and senile keratoses have responded satisfactorily to podophyllin (Kelly & Hartwell, loc. cit.).

During recent years, podophyllin has acquired special importance for its possible use in controlling some forms of cancer; the limiting factor has been the severe gastro-intestinal discomfort which follows its use in high doses. The cytotoxic effect (mitotic arrest, nuclear fragmentation, other evidence of cellular damage) of the drug is similar to that of colchicine. As a karyoplastic, it affects both dividing and non-dividing cells. The mitotic effect has been observed in skin, intestinal mucosa and tumour tissue, after parenteral administration or topical application of podophyllin. At relatively non-toxic dose levels, the peripheral blood leucocytes are reduced, the bone marrow appears hypoplastic, spleen and other lymphatic tissues are decreased in size, the adrenal cortex is depleted of lipid, and marked necrosis and haemorrhage are produced in experimental tumours. The minimum effective dose (to cause appreciable damage to tumour) of podophyllin from *P. hexandrum*, for a single subcutaneous injection in mice bearing implants of Sarcoma 37, was found to be 6 μg./g. body weight (Kelly & Hartwell,

loc. cit.: McCardle & Downing, *Cancer Res.*, 1947, **7**, 717; *Chem. Abstr.*, 1956, **50**, 9599; Nadkarni *et al.*, loc. cit.).

Podophyllotoxin and α- and β-peltatins have high potency in inducing damage in Sarcoma 37 and in a variety of other tumours including adenocarcinoma, carcinoma and melanoma. In case of mice bearing Sarcoma 37, the minimum effective dose of each of the three compounds was about 2 μg./g. for a single subcutaneous injection but several-fold higher doses were required orally. The maximum tolerated dose, in a single injection, was 30–40 μg./g. for these compounds as well as podophyllin. Tumour damage was observed in general as early as 6 hours after injection. 4′-Demethylpodophyllotoxin has also been found to be highly active against Sarcoma 37. The other lignan compounds and their glucosides, and quercetin occurring naturally in podophyllin, are much less active. The tumour damaging potency of the podophyllin compounds is said to be closely associated with their stereochemistry (Leiter *et al.*, *J. nat. Cancer Inst.*, 1949–50, **10**, 1273; Greenspan *et al.*, ibid., 1949–50, **10**, 1295; Kelly & Hartwell, loc. cit.; *Chem. Abstr.*, 1960, **54**, 11296).

The mechanism of the action of podophyllin and its active constituents on tumours is incompletely understood. It has been suggested that the necrosis is a direct consequence of a cytotoxic effect on tumour tissue; a rapid and marked reduction of the cytochrome oxidase was observed in tumour homogenates from animals treated with the podophyllin derivatives. Another hypothesis is that the primary locus of action of the drug is the vascular system, but a number of observers have found no correlation between tumour necrotizing activity and the effect on arterial blood pressure of the drug (Warwadekar *et al.*, *J. nat. Cancer Inst.*, 1952–53, **13**, 393; Leighton *et al.*, *Cancer Res.*, 1957, **17**, 336).

Podophyllotoxin, α-peltatin, and β-peltatin have pharmacological properties similar to those of podophyllin, but cause fewer undesirable or unpredictable side effects, permit precision dosage, and afford a better margin of safety. These crystalline products of podophyllin are commercially available. A number of derivatives of these products have been prepared for their cancer chemotherapeutic studies and their methods of preparation patented. Patents have been taken for preparing stable aqueous solutions of podophyllum glucosides, useful in cases of cardiac insufficiency. Amides of podophyllic and picropodophyllic acids have been found to possess very low toxicity and useful cathartic properties. Clinical trials have indicated that podophyllotoxin is useful in the treatment of *Microsporum audouini* scalp infections (Kelly & Hartwell, loc. cit.; *Chem. Abstr.*, 1961, **55**, 14835, 27788, 22270; 1953, **47**, 12524).

The rhizomes and roots of the plant have been suggested as a source for the preparation of quercetin. The fruits are said to be edible; when they ripen in June–September, they are said to be sought after and gathered by Tibetan boys grazing their yak herd. No details are known about their edible properties. Fruits of the American species *P. peltatum*, when ripe, have a sub-acid, sweetish, peculiar taste, and are sometimes eaten; they are also said to be preserved. When green they are said to be bitter (Nakao, 142; U.S.D., 1955, 1077; Ernst, *J. Arnold Arbor.*, 1964, **45**, 1).

Production and Trade—Most of the Indian drug is obtained at present from plants growing wild, particularly in Jammu and Kashmir, Himachal Pradesh and parts of Uttar Pradesh. Since the supply is made from inaccessible areas, the cost of collection is high and it is difficult to compete with the American Podophyllum (*P. peltatum*) which is offered at a lower rate. Further, the Indian drug samples are not uniform in quality, as the collections are made from localities at different elevations and climatic conditions. The annual supply is at present estimated at 50–80 tonnes from the above localities, while the demand is more than 100 tonnes. It is stated that due to vigorous collection, to meet the increasing demand, there is a fear of depleting the natural growths, since their regeneration is slow. Steps are being advocated to cultivate the plant in suitable places under forestry conditions and assure a more sustained and uniform material (Kapoor & Sarin, *Bull. reg. Res. Lab., Jammu*, 1962, **1**, 38; Chatterjee, *Econ. Bot.*, 1952, **6**, 342; Badhwar & Sharma, *Indian For.*, 1963, **89**, 445).

P. sikkimensis R. Chatterjee & Mukerjee
Rec. bot. Surv. India, 1953, **16**(2), 48.

An erect glabrous herb, 15–30 cm. high, found in Sikkim. Rhizomes stout, globular, 2.3–3.0 cm. × 2.0–4.0 cm.; leaves orbicular-reniform, palmate, 6–8-partite; flowers pink, cup-shaped; fruit an elliptic berry.

The rhizomes and roots of the plant yield a brown resin (7.5%) possessing tumour damaging activity. The resin contains a new lignan lactone designated sikkimotoxin ($C_{23}H_{26}O_8$, m.p. 120°), 3-galactosidyl

Bot. Surv. India. Photo : R. S. Rao

FIG. 61—PODOPHYLLUM SIKKIMENSIS—UNDERGROUND ROOTS

quercetin, quercetin and *iso*rhamnetin. The lactone is said to have properties analogous to those of podophyllotoxin, and on base-catalysed epimerization changes to *iso*-sikkimotoxin (m.p. 220–22°). A more recent investigation has raised doubt to the correctness of the proposed structure or the purity of the lactone (Chatterjee & Chakravarti, *J. Amer. pharm. Ass., sci. Edn*, 1952, **41**, 415; Chakravarti & Chakraborty, ibid., 1954, **43**, 614; Schreir, *Helv. chim. acta*, 1963, **46**, 75).

POECILONEURON Bedd. (*Guttiferae*)

A small genus of two species of evergreen trees indigenous to South India.

P. indicum Bedd.

D.E.P., VI(1), 306; Fl. Br. Ind., I, 278.

TAM.—*Puthangkolli;* KAN.—*Ballagi, kirballi;* MAL.—*Vayila.*

TRADE—*Ballagi.*

A large tree, up to 36 m. or more in height and 2.5–3.0 m. in girth, with a clean straight bole found in the western ghats from North Kanara to Travancore at altitudes of 300–1,200 m.; older trees are often buttressed. Bark dark grey to brown; leaves elliptic, 10–25 cm. long, coriaceous; flowers in terminal panicles, yellowish white, small, fragrant; capsule ellipsoid, 1-seeded.

The tree is generally found on wind-swept ridges and hill slopes with moist well-drained clayey or loamy soil. It grows more or less gregariously, sometimes forming pure patches. It tolerates shade in early stages but becomes a strong light demander with age. Natural reproduction takes place freely by seeds; seedlings are, however, sensitive to drought and large numbers of those which spring up in exposed situations perish in the ensuing hot season. Artificial propagation may be done by transplanting young nursery raised seedlings; notching germinating seeds has also been recommended. Stump planting is not successful. The tree has a moderately fast rate of growth in early stages and attains a height of 2.1 m. in 5 years; an average annual girth increment of 1.1 cm. has been recorded. It coppices well. The tree is attacked by a buprestid borer, *Chrysochora* sp., causing considerable damage to the wood (Troup, I, 22–23; Kadambi, *Indian For.*, 1954, **80**, 323: Mathur, ibid., 1958, **84**, 40).

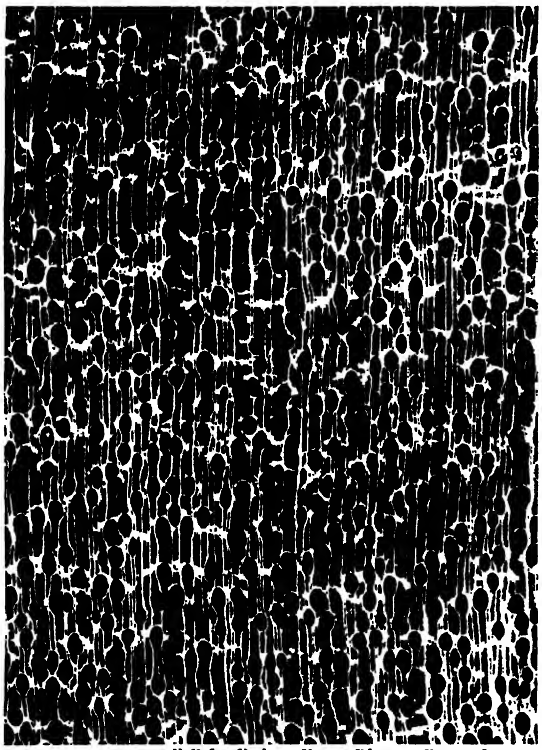
Wood is brownish red with somewhat well demarcated darker heartwood, dull, smooth, straight- or interlocked-grained, medium coarse-textured, tough, very hard and heavy (sp. gr., *c.* 1.14; av. wt., 1,137 kg./cu.m.). Two types of trees, the black and the white, are sometimes distinguished in

F.R.I., Dehra Dun

FIG. 62—POECILONEURON INDICUM

Mysore forests; the former is reported to yield darker, almost black, stronger and heavier wood than the latter. The wood is difficult to season and develops deep surface cracks and end-splits, especially during kiln-seasoning. If left in the log it is liable to develop star shake. It is fairly durable; graveyard tests showed an average life of 5–8 years. The timber is very refractory to treatment, penetration of preservatives being practically nil. It is difficult to saw, but works fairly well both by hand and by machine. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 165; strength as a beam, 140; stiffness as a beam, 150; suitability as a post, 145; shock resisting ability, 145; retention of shape, 45; shear, 180; and hardness, 265 (Pearson & Brown, I, 60–62; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1,** 94; Limaye, ibid., 1954, **1,** 57, Sheet No. 16; Purushotham *et al., Indian For.*, 1953, **79,** 49; Prasad *et al.*, ibid., 1964, **90,** 32; Kadambi, loc. cit.; Indian Woods, I, 84).

Wood is used for heavy constructional work such as beams, trusses, joints and rafters and for bridges.



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 63—POECILONEURON INDICUM—TRANSVERSE SECTION OF WOOD (×10)

It is used also for agricultural implements, rice pounders and walking sticks. Its most important use in Mysore State is for electric transmission poles, after proper seasoning and treatment. The wood is suitable also for railway sleepers and paving blocks [Pearson & Brown, I, 62; Limaye, loc. cit.; *J. Timb. Dryers' & Pres. Ass. India*, 1956, **2**(1), 28; Kadambi, loc. cit.; Trotter, 1944, 208].

Friedelin has been isolated from capsules of the plant (Anjaneyulu *et al., Indian J. Chem.*, 1965, **3,** 237).

P. pauciflorum Bedd. is a tree up to 18 m. in height and 1.9 m. in girth, found in Tirunelveli and hills of Kerala at altitudes of 600–1,500 m., mostly on banks of streams. The wood is reddish in colour, hard and heavy, resembling that of *P. indicum*. It is used for building purposes and for walking sticks.

POGONATHERUM Beauv. (*Gramineae*)

A small genus of annual or perennial grasses found in rocky places in south-eastern Asia and eastwards to Australia and Japan. Three species are recorded in India.

P. crinitum Kunth

Fl. Br. Ind., VII, 141; Blatter & McCann, 25.

A densely tufted grass found more or less all over India up to 1,500 m. Leaves 2.5–7.5 cm. long and 2.5–5.0 mm. broad, linear-lanceolate, more or less hairy; racemes terminal, 2.0–2.5 cm. long with awned spikelets.

The grass grows gregariously on newly exposed soils and along stream banks. It is of little use as fodder, but young parts may be eaten. Analysis of the grass gave the following values (on dry basis): protein, 3.5; ether extr., 1.8; crude fibre, 38.5; carbohydrates, 47.0; mineral matter, 8.0; calcium (CaO), 0.85; and phosphorus (P_2O_5), 0.21% (Bor, 1960, 202; Burkill, II, 1780; Chopra *et al., Indian J. agric. Sci.*, 1956, **26,** 415).

A paste or ashes of the whole plant may be used as an application for skin diseases (Burkill, II, 1780).

P. paniceum Hack. syn. *P. saccharoideum* Beauv.; *Saccharum paniceum* Lam. (Bamboo Grass), a much tufted leafy grass, closely resembling *P. crinitum*, often growing on rocky banks, is found throughout India. The grass is frequently grown as an ornamental pot plant. It is 30–60 cm. high and looks like a dwarf bamboo. It is not eaten by cattle (Bor, 1960, 202; Rhind, 64; Meredith, 486).

Pogonia — *see* **Nervilia**

POGOSTEMON Desf. (*Labiatae ; Lamiaceae*)

A genus of mostly aromatic herbs and shrubs, distributed in the Indo-Malaysian and Sino-Japanese regions. About 30 species occur in India.

The leaves of *P. cablin* yield the Patchouli Oil of commerce which is used in perfumery and medicine, and is imported into India in considerable quantities.

P. cablin Benth. syn. *P. patchouli* var. *sauvis* Hook. f.
PATCHOULI

D.E.P., VI(1), 307 in part ; C.P., 904 ; Fl. Br. Ind., IV, 634.

A much-branched, erect or ascending herb, or an undershrub, up to 1.2 m. high, cultivated in India on a small scale for the extraction of essential oil and also sometimes grown in gardens. Leaves 5–10 cm. x 3–8 cm., ovate, crenate-serrate or lobulate, somewhat tomentose, gland dotted beneath ; flowers white with purple streaks, in contiguous whorls on terminal and axillary spikes.

The origin of *P. cablin* is uncertain. Its occurrence in the Philippines in a state of nature, at places remote from any settlement, indicates that this may perhaps be its native country. It has also been recorded to occur in a wild state in parts of eastern, western and southern India, and some authors have mentioned that it is a native of India and Ceylon. Patchouli is cultivated on a commercial scale in Indonesia and Malaysia and on a small scale in a number of tropical countries in Asia, Africa, and South America (Burkill, II, 1782 : Sampson, *Kew Bull., Addl Ser.*, XII, 1936, 144 ; Menon, *Bull. Indian Cocon. Comm.*, 1954–55, **8,** 25 ; Fl. Java, II, 633 ; Uphof, 72 ; Guenther, III, 553).

Photo : CIMPO, Bangalore

FIG. 64—POGOSTEMON CABLIN—YOUNG PLANTS

In India, systematic cultivation of patchouli was started in 1952, though stray attempts had earlier been made. With a view to determining the most suitable strain, cuttings of Indonesian, Johore and Singapore strains were imported. The crops were raised on a small scale at Mungpoo and Latpanchor by the Cinchona Department, Government of West Bengal ; at Nilgiri and Anaimalai hills under the Government Cinchona Department, Ootacamund ; and at Bangalore by (*i*) the Indian Institute of Science, (*ii*) the Forest Research Laboratory, and (*iii*) the Central Indian Medicinal Plants Organization (CIMPO). At Bangalore, patchouli crops suffered heavily owing to severe nematode infection. Patchouli cultivation has also been tried in Assam, Madhya Pradesh and Kerala. The trials conducted at Bangalore and in the Nilgiri and Anaimalai hills indicated that patchouli can be successfully grown at many places in India. Johore strains have been found to yield better quality oil, though the total yield of leaves as well as oil is reported to be more from the other two strains (Gulati, *Indian Perfum.*, 1963, **7,** 29 ; Virmani *et al.*, *Perfum. essent. Oil Rec.*, 1967, **58,** 618 ; Bhadran, *Bull. reg. Res. Lab., Jammu*, 1963, **1,** 87 ; Srinivasan & Bose, ibid., 1963, **1,** 107).

Patchouli is a hardy plant and adapts itself to a wide range of soils and climatic conditions. It flourishes best on well-drained fertile soil, preferably virgin forest lands, in damp and sub-tropical climates. A deep loamy soil, rich in humus and nutrients, with a loose friable consistency and without impervious layers in the top-soil is said to be the best for optimum oil production. Well-drained alluvial soils which are capable of holding moisture are also suitable. The *p*H of the soil should be 5.5 6.2. The crop requires a fairly heavy and evenly distributed rainfall (150–300 cm.) or periodic irrigation. A temperature of 24–28° and an average atmospheric humidity of 75 per cent are ideal [Soepadyo & Tan Hong Tong, *World Crops*, 1968, **20**(1), 48 ; Gulati, loc. cit.].

Cultivation—Patchouli is cultivated either through seeds or cuttings. Since the crops raised from seeds show a wide variation in the leaf characters and oil yields, cuttings are preferred. They are best raised during the rainy season. It has been found in the plantations of the Government Cinchona Depart-

ment, Ootacamund, that stem cuttings 10.0–12.5 cm. long, consisting of 3–4 nodes, especially with the terminal bud and a crown of leaves, are quite suitable. Recent experiments have, however, shown that 25 cm. long cuttings give higher percentage of rootings than the shorter ones. When there is scarcity of cuttings, single-node cuttings or split-cuttings may be employed, though their initial rate of growth is comparatively slow.

The cuttings are raised in nursery beds at a spacing of 10 cm. × 10 cm. They require irrigation and shade to begin with, but the shade is gradually lessened and ultimately removed about 10 days before transplanting. *Erythrina* spp. may be planted as shade trees. The cuttings are ready for transplanting after about six weeks; under favourable conditions 85–90 per cent of the cuttings strike roots. Experiments conducted at Mungpoo have indicated that by the use of indole acetic acid, the cuttings show early rooting. The cuttings are usually transplanted in the field at a spacing of 90 cm. × 90 cm.; with this spacing a hectare contains about 12,000 plants (Gulati, loc. cit.; Information from Director of Agriculture, Madras; Chatterjee, *Sci. & Cult.*, 1959–60, **25,** 687).

For direct planting, 15–20 cm. long cuttings are planted in the field, 2 or 3 cuttings per planting point. During the early stages shade and sufficient moisture are the chief requirements. The shade is removed after the plants get well established. Experiments carried out in Indonesia have indicated that (*i*) unrooted cuttings seldom get established; (*ii*) cuttings planted at an angle give better results (87%) as compared to those planted erect (59%); (*iii*) cuttings from middle point of the stem give more sprouting than cuttings from the ends; and (*iv*) those from 9 month-old stems seem to give the best planting success (83–90%) as compared to younger and older cuttings (Soepadyo & Tan Hong Tong, loc. cit.).

The plantation requires 3 or 4 interculturings in the first year, and at least twice a year thereafter. The quantity of the oil in the leaves decreases after 2–3 years and its quality deteriorates. Replanting of the crop, therefore, becomes necessary. In Russia, patchouli is grown as an annual crop, and the entire aerial portion of the plant is utilized for the extraction of the oil (Gulati, loc. cit.; Soepadyo & Tan Hong Tong, loc. cit.; Iacobashwili, *Perfum. essent. Oil Rec.*, 1961, **52,** 226).

Patchouli can profitably be grown as a catch crop in rubber and coconut plantations, and also in orchards. At Nossi Be (Malagasy), it is reported to be cultivated in coffee plantations and amongst the trees which support the black pepper vines (Gulati, loc. cit.; Menon, loc. cit.).

Patchouli is a soil-exhausting crop, requiring liberal manuring. The plants respond well to both organic and inorganic nitrogenous fertilizers. It is reported that an application of farmyard manure at the rate of 11,250 kg. together with 228 kg. each of ammonium sulphate and superphosphate per hectare, after each harvest of leaves, results in better yield of leaves. Cowdung manure and fish guano are also said to increase the yield. Foliar application of urea solution seems to benefit growth as well as leaf production (Gulati, loc. cit.; Menon, loc. cit.; Soepadyo & Tan Hong Tong, loc. cit.).

Pests and Diseases—Nematodes attack the roots of patchouli, particularly in wet weather, resulting in wilting, followed by the death of the plant. Injecting the soil with Shell D.D. or Nemagin is an effective control measure, but proves costly in large-scale plantations. Weevils bore into the stems at the nodes; they produce galls, resulting in the drying up of the upper portion. Application of Folidol E605 in a concentration of 50 g. in 100 litres of water is recommended as a control measure. Grasshoppers and scarlet-mite feed upon the leaves and tender shoots. Dusting with 10 per cent BHC controls the grasshoppers. Aromite or Akar 338 is effective against mites. A bacterial disease of patchouli has also been reported; it causes severe damage, especially during the dry weather periods. The leaves gradually become brittle and dry up (Gulati, loc. cit.; Information from the Director, Government Cinchona Department, Ootacamund).

Harvesting and Curing—The first harvesting of the leaves is done 4–6 months after planting, subsequent pluckings being at about the same intervals. Plucking is done in the cool hours of mornings and evenings, before the leaves turn yellow or brown. Young shoots are cut 10–25 cm. below the apex to obtain at least 3–5 pairs of mature leaves; when the growth is vigorous, longer shoots may be plucked. In practice, a few shoots are always left unplucked to ensure better growth for the next harvest. The leaves obtained from first two or three pluckings are reported to yield better quality oil. The data regarding the yield of leaves show a great variation and are inconclusive. Johore and Singapore strains, grown in the Forest Research Laboratory, Bangalore, were estimated to yield 2,000 and 7,000 kg. of air-dry herbage per

hectare per year respectively. In Sumatra, the annual yields have been reported to vary considerably, from 800 to 3,600 kg. of air-dried leaves per hectare. The plantations in Johore (Malaysia) yield about 1,500 kg. per hectare of air-dried leaves at the first plucking and about 900 kg. per hectare from subsequent pluckings. About 1,400 kg. per hectare per annum is considered a fair out-turn (Gulati, loc. cit.; Information from Director of Agriculture, Madras; Guenther, III, 558; Menon, loc. cit.).

Proper curing of the leaves prior to distillation is very important, as it improves both the yield and the quality of oil. The leaves are spread out in thin layers on a hard dry surface in sheds, allowing free circulation of air. Drying directly under the sun results in loss of oil, and the material becomes brittle, turning into powder which is difficult to distil. If the drying is too slow, the leaves remain damp and develop a disagreeable mouldy odour which is also imparted to the oil. During curing, the material is frequently turned over to ensure even and thorough drying and to prevent fermentation. The process of drying normally takes about three days. The cured leaves develop a characteristic patchouli aroma which is less expressed in the fresh ones. After curing, the leaves are cleaned of the foreign matter, larger stalks, and mouldy material (Guenther, III, 559–60; Doraswamy, *Indian Oil & Soap J.*, 1966–67, **32,** 211).

The leaves require special care while packing for export. Even well-cured leaves, if stored loosely for long periods, are liable to develop the objectionable mouldy odour. Compressing and packing the cured leaves immediately into bales ensures best storage. Good preservation is stated to improve the quality of oil.

Patchouli leaves are frequently adulterated with aromatic leaf material from *P. heyneanus, Ocimum basilicum, Hyptis suaveolens, Urena lobata,* and *Microtoena insuavis.* Distilled patchouli leaves, which may still contain a small percentage of oil, are also mixed with the fresh ones (Guenther, III, 560–61).

Patchouli Oil

Patchouli oil is extracted by steam distillation of dried leaves, freed from mature stalks. The yield and quality of oil are influenced by several factors, such as strain of the plant, soil and climatic conditions, condition of the leaves used, and mode of distillation. Analysis of the leaves carried out in Indonesia indicated that the oil content (dry wt. basis) was highest in the buds (5.8%). But the mature leaves (oil content, 5.7%) are said to yield a better quality oil; the young leaves and fallen leaves contain 5.0 and 4.1 per cent of oil respectively. The distillation of the leaves is carried out by means of direct steam generated in a separate steam boiler. The steam pressure employed may vary between 1.4 and 3.5 kg./sq.cm. (20–50 lb./sq.in.). and is carefully regulated. In a modern distillery, it is advisable to alternate between high and low steam pressures. The duration of distillation varies between 6 and 24 hours, depending upon the leaf material to be distilled. Prolonged distillation not only gives a higher yield, but also a better quality oil as the more valuable, odorous compounds of patchouli oil are present in higher boiling fractions. Distillation carried out for too long a period or at too high a steam pressure may, however, yield oils that contain resins of disagreeable odour (Chaco, *Res. & Ind.*, 1958, **3,** 26; Guenther, III, 563–64; I, 114; Gulati, loc. cit.; Doraswamy, loc. cit.; Soepadyo & Tan Hong Tong, loc. cit.).

The yield of oil from good leaf material is reckoned at about 3.5 per cent (dry matter basis). The exporters in Singapore ship the processed bales of patchouli leaves to Europe or America, usually with a guarantee of a minimum content of 3 per cent volatile oil. The yield of the oil from a crop is proportionate to the quality and yield of leaves. Studies carried out at the Indian Institute of Science, Bangalore, indicated that an optimum yield of 60–65 kg. of oil per hectare could be obtained annually if the plants could be raised under most favourable conditions; the yield estimated by the Forest Research Laboratory, Bangalore, was 60 kg. from Johore strain and 142 kg. from Singapore strain. Corresponding yield of oil in the plantations under the Government Cinchona Department, Ootacamund, was estimated at 20–30 kg. per hectare (Guenther, III, 563, 560; Gulati, loc. cit.; Chaco, loc. cit.; Doraswamy, loc. cit.; Subba Rao & Nagesa Rao, 1–12).

Patchouli oil is a viscous liquid, yellowish green to brown in colour, and has warm, powerful and persistent fragrance that improves with aging. The fragrance resembles that of the sandalwood oil. Freshly distilled oil has a somewhat green and harsh aroma. Aging of oil for several years will develop the full, rich and almost fruity aroma, for which patchouli oil is so highly esteemed in perfumery. The physico-chemical characteristics of patchouli oils distilled at Bangalore and the Nilgiri and Anaimalai hills indicate that the oils obtained are of good quality

(Table 1). In the crop grown at Kallar (Madras State), the leaves harvested in January gave a better quality oil with a high laevo-rotation and saponification value after acetylation than those harvested in April or July (Allen, IV, 208; Hill, 187; Guenther, III, 563; Gulati, loc. cit.; Information from the Director of Agriculture, Madras).

Besides subjecting to steam distillation, the leaves are also extracted with volatile solvents to obtain patchouli resinoid. Extraction with benzene gives 4.5–5.8 per cent of a resinoid which contains 70–80 per cent of alcohol-soluble absolute. Patchouli resinoid is a syrupy or very viscous liquid, with dark orange brown colour when extracted with benzene, and pale orange colour when extracted with petroleum ether. It is free from the mustiness encountered in the distilled oil, and has a superior fixative value. The use of the resinoid in soap perfumes is stated to be more economical (Naves & Mazuyer, 282; Gulati, loc. cit.; Poucher, I, 327).

Little is known of the constituents which give patchouli oil its characteristic strong odour. The oil is said to contain about 97 per cent of compounds which have almost no influence on its aroma; of these 40–45 per cent belong to the sesquiterpene group and the balance seems to consist of patchouli alcohol ($C_{15}H_{26}O$, m.p. 56°). The oil contains small amounts of benzaldehyde, eugenol, cinnamic aldehyde, an alcohol with a rose-like fragrance, a ketone with orris-like odour, another ketone, two bases possessing a strong benumbing odour, azulene, and a sesquiterpene alcohol. More recently, β-patchoulene, α-guaiene, α-bulnesene, α-terpinene, cadinene, benzaldehyde and patchouli alcohol were identified chromatographically (Guenther, III, 573–74; Bates & Slagel, *Chem. & Ind.*, 1962, 1715; Kaul & Nigam, *Perfum. essent. Oil Rec.*, 1966, **57**, 91).

Patchouli oil is evaluated by its aroma as well as physico-chemical properties. Good quality oils are characterized by high specific gravity, laevo-rotation, refractive index and good solubility (in 90% alcohol). In commerce, four grades of oil are generally recognized: (*i*) Ordinary; (*ii*) Medium; (*iii*) Special; and (*iv*) Extra-special. The ordinary and medium grades generally correspond to the Indonesian, Malaysian and Singapore oils of commerce, while the special and extra-special grades correspond more closely to the European oils distilled from leaves imported from Singapore or Indonesia (Table 2). The superiority of the European distilled oils over the

TABLE 1—PHYSICO-CHEMICAL CHARACTERISTICS OF PATCHOULI OIL DISTILLED IN INDIA

	Indian Institute of Science, Bangalore[1]			Govt. Soap Factory, Bangalore[1]	Govt. Cinchona Dep., Ootacamund[1] (Nilgiris)	Govt. Quinine Factory, Anaimalais[2]	ISI specifications proposed[2]
	Indonesian strain	Johore strain	Singapore strain	Singapore strain	Johore strain	Johore strain	..
Yield (on dry leaves), %	1.7–2.4	2.5–2.6	1.2–2.9	2.2	3.1	1.5–4.5 (av. 3.0)	..
Sp. gr.$^{15°}_{15°}$	0.9312–0.9395	0.9620–0.9792	0.9857–0.9933	1.0011	0.9532 (at 31°)	0.964–0.981	0.9548–0.9860 (at 25°)
$n^{20°}$	1.5020–1.5050	1.5080–1.5119	1.5205–1.5231	1.5201	1.5040 (at 31°)	1.5040	1.503–1.516 (at 25°)
$[\alpha]^{20°}$	Too dark	−50° to −62°	−25° to −27.6°	−22.5°	−54.8°	−54.1°	−45° to −68°
Acid val.	1.5–3.3	0.4–5.7	1.0–1.7	3.15	0.76	1.4–3.6	5, max.
Ester val.	10.5–13.8	2.1–7.0	6.0–6.4	6.11	3.8	2.7–9.6*	2–14*
Ester val. after acetylation	30.2–50.4	10.7–24.8	39.2–46.2	93.8	..	16.8–18.7	10–28
Solubility in 90% alcohol	Often cloudy up to 10 vol., sometimes, sol. in 0.5 vol.	Sol. in 3–6 vol., clear to cloudy with more	Sol. in 0.5–6 vol., clear to opalescent with more	Sol. in 0.7–1.8 vol., insol. in 1.8–4.8, again sol. up to 10 vol.	Sol. in 5 vol. & more	Sol. in 5 vol. & more	Sol. in 10 vol.

[1] Gulati, *Indian Perfum.*, 1963, **7**, 29; [2] Doraswamy, *Indian Oil & Soap J.*, 1966–67, **32**, 211.
* Sap. val.

TABLE 2—PHYSICO-CHEMICAL CHARACTERISTICS OF COMMERCIAL PATCHOULI OILS

	Indonesia[1] (Sumatra)	Malaysia[2] (Johore)*	Singapore[1]	European distilled[1]
Sp. gr.$_{15^\circ}^{15^\circ}$	0.950-0.990	0.9696-0.9892	0.967-0.972	0.975-0.987
n^{20°	1.5060-1.5160	..	1.5090-1.5100	1.509-1.511
$[\alpha]^{20^\circ}$	-40° to -72	-48.1 to -55.0	-49.7 to -55.7°	-54.0° to -65.5°
Acid val.	0.5-3.0	2.3-3.7	c. 5.0	..
Ester val.	2.0-10.0	2.3-4.1	5.6-10.7†	3.3-9.3†
Ester val. after acetylation		..	16.8-21.5	17.7-22.4
Solubility in 90% alcohol	Soluble	. in 0.5-6.5 vol.	Sol. in 6.5-7 vol., clear to cloudy with more	Sol. in 0.5 vol. & more

[1] Guenther, III, 570-72; [2] Gildemeister & Hoffmann, VII, 466.
* Range of values covers 4 grades of oils. † Sap. val.

TABLE 3—IMPORTS OF PATCHOULI OIL
(Qty in kg. and Val. in Rs.)

	1963-64		1964-65		1965-66		1966-67*		1967-68	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Malaysia	2,812	72,004	2,904	80,541	440	38,393	746	109,153	16,039	273,947
Indonesia	3,246	74,176	3,814	111,904	152	9,082	2,150	368,160	7,818	612,188
Singapore	565	16,343	238	11,314	..	..	113	9,125	1,593	84,342
France	1,177	30,423	1,125	39,841	7,879	358,104	2,174	266,175	1,382	127,064
Others	63	2,367	39	1,641	675	41,170	48	11,304	1,061	109,032
TOTAL	7,863	195,313	8,120	245,241	9,146	446,749	5,231	763,917	27,893	1,206,573

* June 1966-March 1967.

Singapore oils is reported to be due to the better methods of distillation and the conditioning of the leaves in pressed bales during shipment. Patchouli oil is adulterated with cedarwood oil or its higher fractions, and cubeb oil. The addition of cedarwood fractions somewhat sweetens the patchouli note, and it is difficult to detect the adulteration. The resinoid of patchouli is often adulterated with oakmoss resinoid, patchouli oil, clove bud resinoid, vetiver oil residue, and cedarwood oil residue (Guenther, III, 570, 573; Poucher, I, 325; Gulati, loc. cit.).

Roots and stems also contain the essential oil, though in smaller proportion than the leaves. The oil obtained from the roots is of a very high specific gravity and of low quality. The oil from stems is also of inferior grade and, therefore, only leaves are generally used for commercial distillation of patchouli oil. Oil from the stem, distilled at Bangalore from Singapore strain (av. yield, 0.47%), was greenish brown in colour, and possessed an odour of patchouli. It had the following characteristics: sp. gr.$_{15^\circ}^{15^\circ}$, 1.0097; $[\alpha]_D^{20^\circ}$, -48°; n^{20°, 1.5116; acid val., 29.4; ester val., 4.05; acet. val., 49.90; and soluble in 0.5 to 10 vol. of 90% alcohol (Guenther, III, 558; Subba Rao & Nagesa Rao, 11).

Uses—Patchouli oil is one of the most important and valuable raw materials in perfumery industry, and the requirement of the country is met mainly through imports (Table 3). The oil is almost a perfume by itself and is one of the finest fixatives for heavy perfumes. There is hardly any composition of fancy, especially of oriental character, that does not contain patchouli oil. The oil imparts strength and lasting qualities to the composition, and is widely used in soaps, cosmetics, tobacco and incense. It is an excellent masking agent in depilatory creams. The oil gives one of the finest *attars* when blended with sandalwood oil. It also blends well with clove, vetiver, cassia and several other essential oils used in soap industry. Patchouli resinoid, being economical, is increasingly used in soap industry (Guenther, III, 575; Doraswamy, loc. cit.; Gulati, loc. cit.; Guy Lionnet, *World Crops*, 1962, **14**, 336).

The oil is reported to possess antibacterial activity against *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bacterium coli* and *B. typhosum*. It is also effective against *Mycobacterium tuberculosis*. The oil is toxic to *Epistylis* sp. and has irritant effect on the skin of rabbits. In a patented process, the oil has been used as an ingredient of an insect-repellent preparation, especially against moths (George & Pandalai in *Essential Oils & Aromatic Chemicals, Symposium*, Council of Scientific & Industrial Research, New Delhi, 1955, 154; Sirsi *et al.*, *J. Indian Inst. Sci.*, 1952, **34A**, 261; *Chem. Abstr.*, 1955, **49**, 12768).

The dried leaves are used for scenting wardrobes. The leaves and tops are added in baths for their antirheumatic action. In the Philippines, an infusion of the fresh leaves is given in menstrual troubles. The juice of the leaves is applied to repel leeches (Brown, 1946, III, 294; Quisumbing, 830).

P. heyneanus Benth. syn. *P. patchouli* Hook. f. non Pelletier

D.E.P., VI(1), 307 in part; C.P., 904; Fl. Br. Ind., IV, 633.

Hindi—*Pacholi, peholi*; Beng.—*Pachapat*; Mar.—*Patcha, patchapan, mali*; Guj.—*Pachapandi*; Tam.—*Kadirpachai*; Kan.—*Patche tene*; Mal.—*Pachila.*

A highly aromatic herb, up to 1 m. high, widely distributed in most parts of the Deccan Peninsula, ascending to an altitude of about 1,800 m. Leaves 6.5–11.5 cm. or more in length, ovate, crenate, toothed or incised, only sparingly puberulous, membranous; flowers in small distant whorls on slender paniculate spikes.

The herb is probably a native of the Indo-Malaysian region. It is frequently cultivated in India in the areas of its distribution, and is occasionally grown in gardens for its fragrant leaves and flowers. It can be easily propagated through cuttings.

The dried leaves are used for scenting woollens and to keep off moths. Leaves and flowers are made into garlands and chaplets (Chopra, 1958, 581).

The herb is considered to be a diuretic and carminative. In Malaya, a poultice of the leaves is applied to boils, and to relieve headache. A decoction of the leaves is taken for cough and asthma, and that of the roots for dropsy. The powdered leaves are used as a sternutatory. A lotion prepared from the roots is used for rheumatism. The dried shoots are reported to be used for flavouring country liquor (Chopra, Nayar & Chopra, 198; Burkill, II, 1784).

Photo: Ramesh Bedi

FIG. 65—POGOSTEMON HEYNEANUS—FLOWERING BRANCH

The leaves yield an essential oil, which was formerly produced on a small scale in Java under the name Java Patchouli oil or Dilem oil. Since the odour of the oil is inferior to that of patchouli oil, its production was abandoned. Steam distillation of dry leaves from Bangalore plants gave on an average 0.19 per cent of a greenish brown oil, with the following characteristics: sp. gr.$_{15°}^{15°}$, 0.9365; $n^{20°}$, 1.4986; $[\alpha]_D^{20°}$, $-18°$; acid val., 4.35; ester val., 6.27; acet. val., 92.80; and soluble in 0.5–10 vol. of 90 per cent alcohol. The oil yields, obtained from the different parts of the plant, experimentally cultivated in Istanbul, were as follows (dry matter basis): leaves, 0.75; stems, 0.45; and roots, 0.3%. The oil contained patchoulene, patchouli alcohol and eugenol as the chief components (Guenther, III, 553; Subba Rao & Nagesa Rao, 10; *Chem. Abstr.*, 1957, **51**, 18488).

P. parviflorus Benth.

D.E.P., VI(1), 306; Fl. Br. Ind., IV, 632 in part; Kirt. & Basu, Pl. 755A.

Mar.—*Phangla, pangli.*

A much-branched, suffruticose herb, up to 2 m. high, with usually black-purple, angular stems, found

in the Himalayas from Kumaun to Bhutan, and in the hills of Assam and western ghats, ascending to an altitude of about 1,200 m. Leaves very variable in shape, up to 20 cm. long; flowers purplish, in dense whorls on paniculated spikes: nutlets ellipsoid, smooth.

The leaves are reported to be eaten in times of scarcity. They possess a strong odour of black currants and are slightly pungent in taste. They are used as a stimulant and styptic. Bruised leaves are applied as a cataplasm to wounds; the juice is given in colic and fever. Roots are stimulant and antihaemorrhagic. The plant is reported to contain an alkaloid (pogostemonine), trimethylamine, resin and some astringent matter. The leaf extracts are reported to possess antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* (Kirt. & Basu, III, 1976; Dymock, Warden & Hooper, III, 95; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261).

The herb is frequented by bees and is an important source of honey, known as *Pangal* honey in Maharashtra. Experimental trials with this herb have indicated that it is suitable as a green manure for paddy crop. Analysis of the air-dry, tender loppings gave: moisture, 7.60; nitrogen, 1.58; P_2O_5, 0.93; and K_2O, 3.43% [Chaubal & Deodikar, *Indian Bee J.*, 1965, **27**, 1: Khadilkar, *Farmer*, 1960, **11**(11), 6].

P. benghalensis Kuntze syn. *P. plectranthoides* Desf. (Beng.—*Jui-lata, jin, bakoha*; Tel.—*Gondri poolu*; Oriya—*Poksunga*; Garhwal & Kumaun—*Lujra*; Bombay—*Pangla*) is a strongly odorous shrub, up to 2 m. high, with ovate leaves and pinkish white flowers, found almost throughout India, ascending to an altitude of about 1,500 m. in the Himalayas. Medicinal and economic uses are more or less similar to those of *P. parviflorus*. Ashes of the stems are reported to be used as manure for paddy crop. The shrub is occasionally planted for fencing (Kirt. & Basu, III, 1975: Duthie, II, 242; Fl. Assam, III, 510).

On steam distillation, the leaves yield 0.8 per cent of an essential oil, possessing the following characteristics: $d^{20°}$, 0.979; $n_D^{20°}$, 1.5020; acid val., 9.7; ester val., 42.92: and ester val. after acetylation, 50.8. The flower heads contain 0.1 per cent oil with a minty odour. The leaves show antifungal activity against *Helminthosporium sativum* (*Chem. Abstr.*, 1962, **57**, 2353; Bole, *Bull. reg. Res. Lab., Jammu*, 1963, **1**, 117: Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49**, 799).

P. pubescens Benth. syn. *P. parviflorus* Hook. f. (Fl. Br. Ind.) in part is a stout herb, found in the hills of southern India. It is closely related to *P. parviflorus*, and is not discriminated from it for economic purposes.

P. purpurascens Dalz. is a herb with ovate-lanceolate leaves and purplish white flowers, found in the Deccan Peninsula; it has also been recorded from Manipur. Its uses are similar to those of *P. parviflorus* (Kirt. & Basu, III, 1976).

Poinciana — *see* **Delonix**

Poinsettia — *see* **Euphorbia**

Poke, Indian — *see* **Phytolacca**

Pole Cats — *see* **Weasels**

POLEMONIUM Linn. (*Polemoniaceae*)

A genus of perennial herbs distributed in Asia, Europe, western North America extending to Mexico and South America. One species occurs in India.

P. caeruleum Linn. Jacob's Ladder

Fl. Br. Ind., IV, 133: Coventry, Ser. I, 71, Pl. XXXV; Atlas med. Pl. U.S.S.R., 502, Pl. 212.

A tall, erect, perennial herb, 30–120 cm. high, with a creeping rootstock found in alpine western Himalayas from Kashmir to Kumaun, at altitudes of 2,100–3,600 m. Leaves imparipinnate: leaflets lanceolate or ovate-lanceolate; flowers blue, rarely white, corymbose; capsules ellipsoid, overtopped by persistent calyx: seeds oblong-ellipsoid, smooth.

P. caeruleum is a very variable species; it is grown for its showy flowers and attractive foliage. The flowers are frequented by bees for nectar and pollen. Many of its geographic forms are sometimes ranked as species: var. *himalayanum* Baker (syn. *P. himalayanum* Baker) with large lilac-blue or darker flowers occurs in the Himalayas (Bailey, 1947, III, 2729: Howes, 1945, 156).

The plant is slightly bitter in taste and is considered sudorific and astringent. All parts of the plant, particularly the roots, contain triterpene saponins; yields up to 20–30 per cent of saponins have been obtained from roots of 1–2 year old plants. The haemolytic index of individual saponins varies from 100,000 to 200,000. Besides saponins, the roots contain resin (1.3%), organic acid and essential oil. The root can be used as a substitute for senega root (from *Polygala senega* Linn.). Alcoholic extracts of the roots possess an expectorant action superior to that of senega. They are also reported to be sedative (Steinmetz, II, 354: Atlas med. Pl. U.S.S.R., 504; *Chem. Abstr.*, 1945, **39**, 2847: 1944, **38**, 4099).

The seeds (protein content, 23.9%, dry basis) yield *c.* 26 per cent of an oil having the following values: $n_D^{40°}$, 1.4709; iod. val., 150; and sap. val., 190. The fatty acid composition of the oil is as follows: oleic, 33; linoleic, 60; linolenic, 3; and conjugated triene acid, 1.3% (Earle *et al.*, *J. Amer. Oil Chem. Soc.*, 1959, **36**, 304).

POLIANTHES Linn. (*Amaryllidaceae*)

A small genus of herbs distributed in tropical America. One species is introduced into India and grown as an ornamental plant for its fragrant flowers.

P. tuberosa Linn. TUBEROSE

D.E.P., VI(1), 312; Bailey, 1947, III, 2731, Fig. 3093.

HINDI *Gulcheri, gulshabbo;* BENG.—*Rajanigandha;* TEL.—*Sukandaraji, nelasampengi;* TAM.—*Nilasampangi;* KAN.—*Sugandharaja, nelasampinge, sandharaga.*

An erect herb, 60–120 cm. high, with stout tuberous rootstock; leaves basal, linear, those on the stem much shorter; flowers funnel-shaped, waxy white, fragrant, in long terminal racemes.

P. tuberosa is believed to be a native probably of Mexico or the Andes of South America. If it is considered a Mexican species, it is supposed to have originated from *P. gracilis* Link & Otto as the former is not known to grow wild. It is cultivated in gardens almost throughout India. It makes a good pot plant as well, and is sometimes grown in artificial rockeries. It is cultivated in the Grasse region of South France and in Morocco for the extraction of its flower oil. In India, it is cultivated on a commercial scale, in about 200 hectares (500 acres) round about Devanahalli (Bangalore dist.) and also in Tumkur and Mysore. There are several interesting forms, some being dwarf. There are also single- and double-flowered forms. The single-flowered forms are more strongly scented than the double-flowered ones and are exploited for the extraction of its perfume. The double-flowered forms are usually preferred for growing in gardens. There are several named forms of which *Pearl* is the best [Bailey, 1947, III, 2731; Chittenden, III, 1621; Jindal, *Indian Hort.*, 1957–58, **2**(2), 20; Guenther, V, 343; Firminger, 328; Percy-Lancaster, 388].

Tuberose is propagated by offsets; it can be raised from seeds as well. It grows in sunny or semi-shady situations. It thrives in a well worked medium clayey soil, but it does better in a loose, friable soil. The land

FIG. 66—POLIANTHES TUBEROSA—FLOWERING BRANCH

is prepared by applying well decayed farmyard manure. Large-sized bulbs are planted from April to May onwards in rows about 22–30 cm. apart, and about 5 cm. deep. After the bulbs are planted, no particular care is needed except weeding and watering when necessary. Application of a small dose of nitrogenous and phosphatic fertilizers at the time of sprouting of the bulbs gives extra size to flowers and produces longer stalks. The stems should be supported by stakes. For pot culture, big-sized bulbs are put in 30 cm. pots, and are allowed to remain in moist soil till the leaves appear; watering is done liberally afterwards. In about three months after planting, the central shoot develops bearing clusters of white flowers. Single flowers are plucked as they open day after day and sent to the market packed in baskets. The average yield of flowers (fresh) is about 17,500 kg. per hectare. To obtain a succession of flowers, the dormant bulbs should be planted at an interval of a few weeks. Bulbs are collected after the flowering is over and the leaves have decayed and died down; they are used as seed-stock for the next

season. Usually the bulbs should be lifted every two or three years, rested and cured and the offsets transplanted [Gopalaswamiengar, 497; Jindal, loc. cit.; Percy-Lancaster, 388; Desai, *Indian Fmg, N.S.*, 1957–58, **7**(1), 10; Firminger, 328; Information from Scientist-in-charge, Central Indian Medicinal Plants Organization (CIMPO), Bangalore].

The plant is subject to a disease caused by *Sclerotium rolfsii* Sacc. It manifests itself on the leaves at or near the soil surface. The infected spots lose green colour due to rotting and extend and cover the whole leaf; such leaves become detached from the plant and fall to the ground. Infected plants become weak and produce few or no flowering shoots in case of severe damage (Das, *Sci. & Cult.*, 1961, **27**, 549).

The flowers of the plant are durable although brittle, remain fresh for pretty long time and stand long distance transportation due to their waxy nature. They are used for garlands, bouquets and button-holes. The long flower spikes are excellent as cut flowers for table decoration when arranged in bowls and vases. The flowers are used in Java in vegetable soup (Desai, loc. cit.; Jindal, loc. cit.; Gopalaswamiengar, 497; Burkill, II, 1785).

The flowers of tuberose emit a most delightful fragrance and are the source of Tuberose Oil used in high-grade perfumery. Like the jasmine, the tuberose flowers continue to develop their delightful perfume for some time after they have been harvested; the perfume is, therefore, best extracted by the process of enfleurage. Steam distillation gives an oil, poor in yield and quality. For the purpose of enfleurage, only freshly picked flowers which are still closed are preferred. About 150 kg. of flowers are required to produce 1 kg. of a brown semi-solid absolute of enfleurage. The extracted flowers still contain some natural perfume and are treated with petroleum ether to obtain the absolute of chassis as a valuable by-product (yield 1.2–1.5%). In recent years, the process of enfleurage has been partly replaced by solvent extraction which requires much less labour though the yield of the absolute is reduced considerably. Extraction of the tuberose flowers with petroleum ether yields 0.08–0.11 per cent of concrete which gives 18–23 per cent of absolute on treatment with alcohol and contains 3 6 per cent steam distillable oil (Guenther, V, 343–45; Naves & Mazuyer, 246).

Concrete of tuberose (congealing p., 49–50°) is a light to dark brown, waxy and rather hard mass, only partly soluble in high-proof alcohol. The absolute is a highly viscous or semi-liquid brownish mass with powerful and lasting odour, truly reminiscent and characteristic of the living flowers. The characteristics of a sample of genuine absolute are as follows: congealing p., 21–22°; sp. gr.$^{25°}$, 0.982; $n^{25°}$, 1.4916; acid val., 84.6; and ester val., 138.2. The steam volatile oil obtained from the absolute has the following physico-chemical properties: sp. gr.$^{15°}$, 1.007; $[\alpha]_D$, −3.75°; acid val., 22.0; ester val., 224.0; methyl anthranilate content, 1.13%. The tuberose oil contains geraniol and nerol (both free and as acetates), farnesol, benzyl alcohol, benzyl benzoate, methyl salicylate, methyl anthranilate, eugenol and butyric and perhaps phenylacetic acids. Methylvanillin and piperonal have also been identified in the oil (Guenther, V, 346–47; *Chem. Abstr.*, 1956, **50**, 8971).

The absolute obtained through volatile solvents is one of the most expensive natural flower products and is used in perfumes of only the highest grades. The commercial tuberose absolutes are usually the blends in which absolute of enfleurage predominates. The perfume is employed in scents of the heavier type, floral as well as oriental. Tuberose flower oil is an important base, particularly in gardenia perfumes (Poucher, II, 252; Guenther, V, 348).

The bulbs are reported to contain an alkaloid, lycorin, which causes vomiting. Two steroidal sapogenins, namely hecogenin (m.p. 265°) and a small amount of tigegenin (m.p. 207°), and a polyfructosan (yield 7%) have been isolated from the bulbs. Presence of a transfructosidase has also been observed (Burkill, II, 1785; *Chem. Abstr.*, 1955, **49**, 5592; 1939, **33**, 3837; Srinivasan & Bhatia, *Curr. Sci.*, 1954, **23**, 192; Bhatia & Srinivasan, *J. sci. industr. Res.*, 1954, **13B**, 373).

The bulbs are considered diuretic and emetic. The bulbs are dried, powdered and used as a remedy for gonorrhoea. In Konkan, the bulbs are rubbed with turmeric and butter and applied as a paste over red pimples of infants (Kirt. & Basu, IV, 2474).

POLLIA Thunb. (*Commelinaceae*)

Fl. Br. Ind., VI, 367.

A small genus of herbs distributed in the moist parts of the Old World tropics. Five species are recorded in India.

P. secundiflora Bakh. f. syn. *P. sorzogonensis* Endl., a large herb or undershrub with a stout viscid stem and linear or elliptic-lanceolate leaves, 15–25 cm. ×

5–8 cm., is distributed in the eastern Himalayas and in southern India at an elevation of 800–900 m. It bears white or pale pink flowers and small, globose, bright blue, many-seeded fruits, *c.* 8.0 mm. diam. The fruits are said to be eaten (Burkill, II, 1785).

Pollinia — *see* **Eulalia, Microstegium**

Pollinidium — *see* **Eulaliopsis**

POLYALTHIA Blume (*Annonaceae*)

A large genus of shrubs and trees distributed in the tropics of the Old World. About 12 species occur in India.

P. cerasoides Bedd.

D.E.P., VI(1), 313; Fl. Br. Ind., I, 63; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 65, Pl. 76B.

HINDI *Kudumi*; MAR.—*Hoom, uma*; GUJ.—*Uma*; TEL. *Gutti*; TAM.—*Nakulsi, mullili*; KAN.—*Nettalingamara, sannahesare*; MAL.—*Narelai*; ORIYA—*Potmossu*.

SANTAL—*Panjon*.

A small to moderate-sized tree, up to 15 m. in height and 1.0 m. in girth, with a clear bole up to 7.5 m., distributed in Bihar and Orissa, and in Assam up to 900 m., and from Khandesh to Travancore in the west. Bark black to light grey, rough, thin; leaves oblong-lanceolate; flowers greenish white, fragrant; fruits a cluster of ovoid, 1-seeded carpels, dark-red, fleshy and sweet.

The plant occurs on dry hills, monsoon and deciduous forests, and sometimes in evergreen forests, but is nowhere common. It is also cultivated. It reproduces by root suckers and regeneration is high (Troup, I, 10; Indian Woods, I, 22).

The wood is light, olive-grey with a faint yellowish cast, heartwood not distinct, lustrous, smooth, straight-grained, even- and medium fine-textured, hard and moderately heavy (sp. gr., 0.69; wt., 689–833 kg./cu.m.). If the wood is not carefully seasoned, it is liable to develop fine, long, deep cracks. Green conversion and slow seasoning, preferably water seasoning, are recommended. The timber is fairly durable under cover. It is easy to saw, planes to a fine smooth surface and works well on a high speed lathe, finishing to a bright surface. It takes good polish (Pearson & Brown, I, 26–27; Gamble, 17; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1**, 75).

The wood is used for house construction, planks, rafters, packing cases and cots and for boat building. It is suitable for turnery, joinery work, bobbins and boot lasts. It is a good fuel wood; calorific value: 4,929 cal., 8,873 B.t.u. (Pearson & Brown, I, 27; Trotter, 1944, 199; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

The fruit is said to be eaten (Haines, II, 13).

P. fragrans Bedd.

Fl. Br. Ind., I, 63; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 72, Pl. 100A.

TAM. & MAL.—*Nedunar*; KAN.—*Gauri, habbe*.

A tall, buttressed tree, 25 m. or more in height and *c.* 1 m. in girth, found often gregarious in the evergreen tropical forests of western ghats from Konkan southwards up to an altitude of 1,200 m. Bark grey, smooth; leaves oblong-lanceolate, flowers fragrant, greenish yellow; fruit a cluster of ovoid, purple coloured carpels.

The wood is greyish white, straight-grained, medium fine-textured, soft to moderately hard and light (sp. gr., 0.531–0.680; wt., 448–673 kg./cu.m.). It is liable to crack during seasoning. Kiln seasoning of 2.5 cm. thick planks takes 13–16 days; in addition to initial steaming two intermediate and one final

FIG. 67—POLYALTHIA FRAGRANS—FLOWERING AND FRUITING BRANCH

F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 68—POLYALTHIA FRAGRANS—TRANSVERSE SECTION OF WOOD (×10)

steaming at 55°/100 per cent R.H. for 2–4 hours may be needed. The timber is not durable. Graveyard tests showed an average life of less than 2 years. It is easy to work, peel and finish. It is said to show practically no corrosive effect on metals. The data for the comparative suitability of the timber expressed as percentages of the same properties of teak are: wt., 85; suitability as a post, 85; shock-resisting ability, 80; retention of shape, 60; shear, 80; and hardness, 70. Newly felled wood is subject to attack by borers (*Platypus* spp.) [Gamble, 18; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 57, Sheet No. 16; Limaye & Sen, ibid., 1953, **1**, 75; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956, 3; Purushotham, *J. Timb. Dryers' & Pres. Ass. India*, 1959, **5**, 1; Purushotham *et al., Indian For.*, 1953, **79**, 49; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 48].

The wood is used for light construction, furniture, match-boxes and splints, packing cases and masts. It is suitable for body, wings and spars of aeroplanes, and has been suggested as a possible alternative for *Pinus* and *Abies* woods for this purpose. It can also be used for tennis and badminton racquets, billiard cues, picture and slate frames, and for commercial plywood. It is a good fuel wood; calorific value: sapwood—5,043–5,176 cal., 9,152 B.t.u. (Limaye, loc. cit.; Trotter, 1944, 190, 216, 218, 225, 227; Limaye, *Indian For. Rec., N.S., Util.*, 1942, **2**, 168; *Indian For.*, 1952, **78**, 274, 357; Rehman *et al.*, ibid., 1954, **80**, 626; ibid., 1948, **74**, 279; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

A new diterpene acid, polyalthic acid ($C_{20}H_{28}O_3$, m.p. 102°), has been isolated from the stem bark in a yield of about one per cent (Gopinath *et al., Helv. chim. acta*, 1961, **44**, 1040).

P. longifolia Thw. MAST OR CEMETERY TREE

D.E.P., VI(1), 313; Fl. Br. Ind., I, 62; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 72, Pl. 99.

*HINDI—*Asoka, debdari*; BENG.—*Debdaru*; GUJ.—*Asopalav*; TEL.—*Nara maamidi*; TAM.—*Nettilingam, assothi*; KAN.—*Kambadamara, hessare, ubbina*; MAL.—*Arana, chorana*; ORIYA—*Debdaru, asupal*.

ASSAM—*Unboi*.

A tall, handsome, evergreen tree with a straight trunk, considered to be a native of the drier parts of Ceylon, very commonly cultivated all over India, in gardens and avenues. Bark smooth, greyish brown, thick; leaves glossy green, lanceolate with undulate margins; flowers in fascicles, yellowish green; fruit a cluster of small ovoid, purple, 1-seeded carpels.

There are also forms of this tree with markedly drooping branches. The tree grows well in moist and warm localities. Propagation is through direct sowing of seeds at site or planting 2-year old seedlings raised in pots or baskets. The seeds retain their viability for one season only and should be sown in August. It has been recommended for growing in tall hedges. It is reported to be subject to die-back disease caused by a species of *Phomopsis*. A number of defoliating larvae and a few other insect pests have also been recorded [Chaturvedi, *Indian Fmg, N.S.*, 1956–57, **6**(9), 43; Troup, I, 10; Gopalaswamiengar, 184, 246; Das Gupta & Kamal, *Proc. Indian Sci. Congr.*, 1953, pt III, 79; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 48].

*The name *Asoka* is sometimes indiscriminately used in several Indian languages for both *P. longifolia* and *Saraca indica* Linn. but it is believed that the name is correctly applied to the latter tree. Similarly, the name *Devadaru* in one form or other is also used indiscriminately for *Polyalthia* spp. as well as for *Cedrus deodora*. However, the latter is the true *Devadaru*.

FIG. 69—POLYALTHIA LONGIFOLIA—GROWN IN GARDEN

The wood is yellowish or whitish, tolerably close- and even-grained, soft, flexible and light (wt., 587–641 kg./cu.m.). It is used for making barrels, drums and boxes, and for scaffolding and carriage shafts. It is reported to be suitable for packing cases, pencils and matches; the tall straight trunks were formerly used for masts (Gamble, 18; Talbot, I, 22; Bourdillon, 5; Lewis, 6; Fl. Assam, I, 31; Cowen, 79).

The fruit is reported to be eaten in times of scarcity. The leaves are somewhat aromatic and are commonly used for decoration. The bark is also used as a febrifuge in some parts of India and is often employed as substitute or adulterant of the bark of *Saraca indica*. They can be distinguished from one another by macroscopical and microscopical characters and by the behaviour of the bark powders when treated with chemical reagents and by their fluorescent character. In experimental animals, the aqueous extract of the bark stimulates the isolated ileum and uterus; it depresses the heart, lowers blood pressure and stimulates respiration [Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 17; Kirt. & Basu, I, 72; Achari & Lal, *Indian Pharm.*, 1952, **7**, 538; Prasad *et al.*, *J. sci. industr. Res.*, 1961, **20C**, 125].

P. simiarum Hook. f. & Thoms.

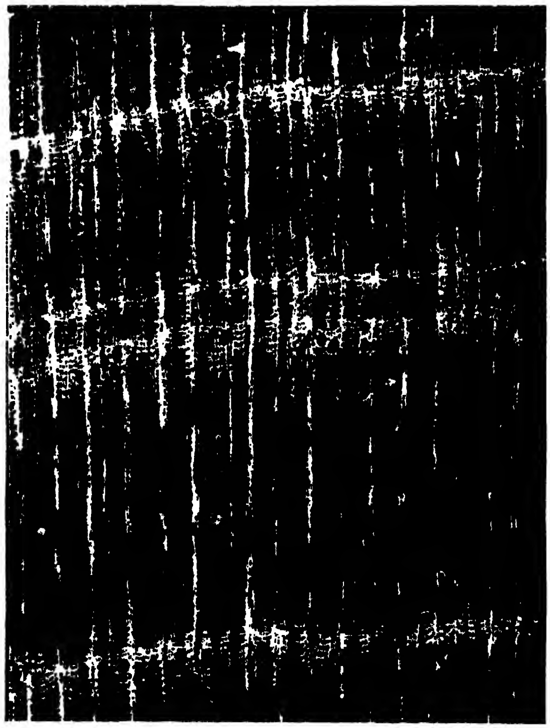
D.E.P., VI(1), 314; Fl. Br. Ind., I, 63; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 73, Pl. 101.

ORIYA—*Wojarh, mongai.*

ASSAM—*Boga-khamtou, bor-koliori*; KHASI—*Dieng-lar-sei, dieng-ja-roi*; LUSHAI—*Hreirawt*; SANTAL—*Dighi bentia*; NEPAL—*Labshi, khutti.*

A tall tree, up to 30 m. in height and 2.4 m. in girth, with a straight, cylindrical trunk, found in the foot-hills of eastern Himalayas, in Assam and North Bengal and extending to Bihar and Orissa and the Andaman Islands. Bark grey, smooth, fibrous; leaves elliptic or oblong-lanceolate; flowers greenish yellow, in fascicles; ripe carpels fleshy, orange red to bluish black.

The tree is suitable for planting in tea estates in the foot-hills and plains of North Bengal and Assam. It prefers a slightly moist, but well drained soil. Propagation is through direct sowing or planting one year old, nursery raised seedlings at a spacing of 1.8 m., preferably in alternate lines with fast growing light-demanders. The tree regenerates itself naturally under suitable conditions. Newly felled wood is reported to be susceptible to attack by a number of borers [Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 97; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 49].



F.R.I., Dehra Dun. Photo: Ramesh Ra

FIG. 70—POLYALTHIA SIMIARUM—TRANSVERSE SECTION OF WOOD (×10)

The wood is pale olive yellow, without distinct heartwood, straight-grained, even- and medium fine-textured, with a somewhat rough feel, strong, moderately hard and heavy (sp. gr., 0.71 ; wt., 561–705 kg./cu.m.). The timber may develop serious splits if left in the log. Green conversion and open stacking are recommended. It is not difficult to saw or work but finishes to a poor surface (Pearson & Brown, I, 24–25 ; Fl. Assam, I, 31 ; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1**, 75 ; Indian Woods, I, 23, appx I, 256).

The wood is suitable for tool handles, sports goods, match-boxes and splints, veneers, tea chests and electric transmission poles. Bark yields a fibre which is made into ropes (*For. Res. India*, 1941–42, pt I, 45 ; Pearson & Brown, I, 25 ; Trotter, 1944, 209).

P. suberosa Thw.

D.E.P., VI(1), 314 ; Fl. Br. Ind., I, 65 ; King, *Ann. R. bot. Gdn Calcutta*, 1893, **4**, 64, Pl. 77B.

HINDI—*Cham-khirni ;* BENG. -*Bara chali ;* TEL.—*Chilaka duduga ;* ORIYA—*Karadia, burhi chamri.*

ASSAM—*Makhamsra-phang, habida cha, bandor kola ;* SANTAL—*Sandiome.*

A large shrub or small tree, found throughout the greater part of India, extending from Assam to Uttar Pradesh in the north and Kerala in the south. Bark brownish, rugged and corky ; leaves generally oblong ; flowers solitary, greenish, yellowish or reddish brown ; ripe carpels small, sub-globose, red or black.

The wood is olive grey, close-grained, hard, tough, moderately heavy (wt., 640–720 kg./cu.m.) and durable. It is used for carpentry, masts and spars of small boats and generally for the same purposes as the wood of *P. cerasoides* (Gamble, 17 ; Indian Woods, I, 23 ; Benthall, 8).

The fruit is edible. A decoction of the fresh roots is reported to be used as abortifacient in the Philippines. The tree is a host for the lac insect [Quisumbing, 317 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 49].

P. coffeoides Thw. (TAM.—*Nedunarai ;* MAL.—*Villa*) is a moderate-sized to large, spreading tree found in the western ghats from South Kanara southwards, ascending up to an altitude of 1,200 m. ; sometimes cultivated as an ornamental plant. The bark is made into ropes. The timber is straw-coloured, hard and heavy. It is subject to the attack of a borer but debarked logs are not liable to attack of the insect (Cameron, 4 ; Worthington, 9 ; Khan, *Indian For. Bull., N.S.*, No. 136, 1947).

P. jenkensii Hook. f. & Thoms. (Fl. Br. Ind.) in part syn. *P. andamanica* Kurz (ASSAM—*Koliori, kola-khamtow, titahachi ;* KHASI —*Dieng-ther ;* NEPAL —*Kalikath*) is a medium-sized tree found in Assam and the Andamans. The wood is reported to be used for house posts, boxes and poles and is suitable for tea boxes (Gamble, 17 ; Fl. Assam, I, 32).

POLYCARPAEA Lam. (*Caryophyllaceae*)

A cosmopolitan genus of annual or perennial herbs. Seven species occur in India.

P. corymbosa Lam.

D.E.P., VI(1), 314 ; Fl. Br. Ind., I, 245 ; Kirt. & Basu, Pl. 94.

GUJ.—*Jinapanano oghrad ;* TEL.—*Bommasari, rajuma ;* TAM.—*Nilaisedachi ;* KAN.—*Powdemullu gida ;* ORIYA—*San jatjatia.*

DELHI—*Machechi, dholphuli ;* MUNDARI—*Ote chandoa ;* SANTAL—*Janhe nanjom.*

An erect, much-branched annual or perennial herb, 15–45 cm. high, found in sandy and rocky places, and in fields and waste places almost throughout India, ascending up to 2,100 m. in the Himalayas. Leaves long, narrow-linear, mucronate ; flowers small, in dense, terminal corymbs ; capsules very small, shining, brown.

The plants are said to be grazed by domestic stock. The leaves of the plant are pounded and applied as poultice, warm or cold, over boils and inflammatory swellings ; they are given in the form of pills with molasses in jaundice. In Malaya, the flowering head along with the portion of stem and leaves is used as demulcent and astringent (Dalziel, 29 ; Kirt. & Basu, I, 240).

POLYCARPON Linn. (*Caryophyllaceae*)

Fl. Br. Ind., I, 244 ; Fl. Delhi, Fig. 20.

A genus of annual or perennial herbs distributed in warm and temperate regions of the world. Two species are recorded from India.

P. prostratum (Forsk.) Aschers. & Schweinf. syn. *P. indicum* (Retz.) Merrill ; *P. loeflingii* Benth. & Hook. f. (HINDI—*Sureta ;* BENG.—*Ghima*) is an erect or diffuse, glabrous or hairy annual or perennial herb with linear-oblong or spathulate leaves and small flowers in numerous-flowered crowded cymes found as weed in fields and waste places in Punjab, Mt. Abu, upper Gangetic plain, Nepal, Bihar, West Bengal, Madras, Deccan, western ghats, Mysore and Gujarat.

In Indo-China, an infusion of roasted leaves is given for cough following fever, more particularly measles (Caius, *J. Bombay nat. Hist. Soc.*, 1936–37, **39**, 565).

POLYGALA Linn. (*Polygalaceae*)

A large genus of herbs, undershrubs or shrubs distributed in the warm temperate regions of the world. About 20 species occur in India.

P. senega, indigenous to North America, is the source of the drug Senega.

P. abyssinica R. Br. ex Fresen.

Fl. Br. Ind., I, 202; Mukherjee, *Bull. bot. Soc. Beng.*, 1958, **12**, 41.

A small perennial herb, 20–50 cm. high, distributed in the Himalayas from Kashmir to Kumaun, up to an altitude of 3,000 m. Rootstocks woody, 4–6 mm. diam. at the base, yellowish brown to earthy brown: leaves narrow-linear, 1–4 cm. long and 2–3 mm. broad; flowers pink or purple, in terminal racemes.

The roots have a short and smooth fracture. They are acrid in taste and odourless. They are found to possess frothing and haemolytic activity, indicating the presence of saponin. Study of the expectorant action of the roots, for their possible use as a substitute for senega, has been suggested. Saponin is absent in the leaves and stem (Shah & Pandhe, *Indian J. Pharm.*, 1960, **22**, 66).

P. arillata Buch.-Ham. RED-EYE or YELLOW MILKWORT

Fl. Br. Ind., I, 200; Mukherjee, *Bull. bot. Soc. Beng.*, 1958, **12**, 31; Fyson, I, 33; II, Pl. 21.

BENG.—*Nepali-kanti.*

KHASI—*Dieng-soh-tynka, dieng-ja-kyba*; NEPAL—*Marcha, karima*; LEPCHA—*Michepnor-kung, cleem-soom-creem.*

A large shrub, up to 4.0 m. high, found in the Himalayas from Nepal to Assam and in the hills of South India, at altitudes of 600–2,800 m. Leaves elliptic or oblong-lanceolate, caudate-acuminate: flowers bright yellow, in drooping racemes; capsules fleshy, sub-orbicular, rugose when dry. Some taxonomists consider the North Indian plant as a distinct species, *P. tricholopha* Chodat.

The roots are reported to be used as a purgative and febrifuge, and also for headache. They are used by the Sherpas to ferment *murwa* beer (Biswas, 33; Cowan & Cowan, 16).

P. chinensis Linn. syn. *P. telephioides* Willd.; *P. brachystachya* DC., non Blume

D.E.P., VI(1), 315; Fl. Br. Ind., I, 204; Kirt. & Basu, Pl. 91B.

HINDI—*Meradu, miragu*; BENG.—*Meradu*; MAR.—*Negri, phuntani*; GUJ.—*Pilibhonyasna.*

SANTAL—*Gaighura*; MUNDARI—*Bir mindi tasad.*

A very variable, erect, decumbent or ascending, often pluricaulous annual, up to 30 cm. high, found throughout the plains of India, ascending up to an altitude of *c.* 1,500 m. and in the Nicobars. Rootstocks slender; stem angular at the top; leaves varying from oblong-ovate to lanceolate; bracts persistent; flowers in axillary or extra-axillary racemes, shorter than the leaves, yellowish or blue to violet; capsules didymous, oblong; seeds oblong, black, hairy, winged.

Tender leaves are often used as food, especially in scarcity areas; they possess a pleasant flavour and are said to be wholesome. An infusion of the leaves is prescribed for asthma, chronic bronchitis and catar-

FIG. 71—POLYGALA CHINENSIS

rhal affections. The roots are reported to be used for fever and dizziness. They are reported to possess antiseptic properties (Kirt. & Basu, I, 234; Chopra, 1958, 599).

The Chinensis Roots of the Indian pharmacopoeal works, mentioned as a substitute of true senega, were supposed to have been derived from 3- or 4-year old plants of *P. chinensis*; but, *P. chinensis* is an annual herb. The anatomical structure of the chinensis roots available in the market shows 3–5 rings of secondary growth, indicating that the source of these roots must be some perennial plants. It appears that the confusion arose as some authors considered *P. glomerata* as a synonym of *P. chinensis*. The two species are considered distinct by all Indian floras and the floras of Java and Siam. While *P. glomerata* is a perennial robust plant with caducous bracts, found from Sikkim to Assam and further east in Burma and Malaysia, *P. chinensis* is merely an annual with persistent bracts, distributed in the plains throughout India. The roots of *P. chinensis* are so thin that their commercial exploitation is not economical, even though they are reported to contain considerable quantities of saponins. *P. chinensis* and its preparations were, therefore, deleted from I.P. (Gupta & Bal, *J. sci. industr. Res.*, 1952, **11B**, 116; Merrill, *Trans. Amer. phil. Soc., N.S.*, 1935, **24**, 228; Mukherjee, *Bull. bot. Soc. Beng.*, 1958, **12**, 41; Haines, II, 41; Fl. Assam, I, 98; Fl. Madras, 58; Fl. Java, I, 198; Craib, I, 101; Adema, *Blumea*, 1965–66, **14**, 253; Shah *et al.*, *Indian J. Pharm.*, 1957, **19**, 10; Shah & Pandhe, ibid., 1960, **22**, 66; I.P., suppl., XV).

P. glomerata Lour.

Fl. Br. Ind., I, 206; Fl. Java, I, 198; Fl. Assam, I, 98.

A much-branched, undershrub or a perennial herb, *c.* 60 cm. high, distributed in the eastern Himalayas from Uttar Pradesh to Assam. Rootstock woody; leaves linear-lanceolate, oblong or elliptic; flowers green or white, with a violet central blotch, in racemes which are mostly supra-axillary; fruit a broad capsule.

A decoction of the shoots is given in inflammatory conditions. The leaves enter into a compound given as a remedy in diarrhoea. An infusion of the herb is given in asthma and chronic bronchitis and is also used as a tonic. The plant contains methyl salicylate and a saponin (Kirt. & Basu, I, 234; Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 41; Burkill, II, 1789–90).

P. senega Linn. SENEGA

D.E.P., VI(1), 316; Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, Fig. 45.

A pluricaulous, perennial herb, 20–30 cm. high, indigenous to North America. Leaves mostly linear-lanceolate to elliptic or ovate; flowers white, in terminal racemes; fruits 2-celled capsules.

This herb is valued for its roots, which constitute the Senega of commerce. It is not found in India but has been suggested for cultivation in the temperate Himalayas and in the Nilgiris at altitudes of 1,200–2,100 m., which are likely to be suitable localities (Nayar & Chopra, 43; Krishnamurthi, 146).

Senega thrives in the open and also in partial shade. It grows in any type of soil, containing a fair amount of leaf-mould. It can be propagated either by seed or by rootstocks. The seedlings cannot withstand frost in the first year and need protection. The plants grow slowly and nearly 4-year old plants yield roots of the required size. They are cleaned and dried for commerce.

The drug senega consists of dried rootstocks and roots obtained from 3- or 4-year old plants. The rootstocks are yellowish orange to brownish conical pieces, 5–20 cm. long and 2–12 mm. in diameter. They are sweetish, and acrid in taste. The odour is characteristic, recalling that of methyl salicylate. The powdered senega has a tendency to cause sneezing. Senega is used as an expectorant in chronic bronchitis and asthma. In overdoses, the root acts as an irritant poison producing violent vomiting and purging (Gupta & Bal, *J. sci. industr. Res.*, 1952, **11B**, 116; U.S.D., 1955, 1225–26).

According to earlier work, the active principles in the roots are two saponins: senegin and polygalic acid, which are present to the extent of 5–10 per cent. The saponins are irritant to mucous membrane of the stomach and also give rise to a reflex secretion of mucus in the bronchioles. Later research indicated that the roots contain only one saponin, senegin, which on hydrolysis with hydrochloric acid yields two sapogenins: senegenin and polygalic acid (senegenic acid). Recent work has, however, established that the primary sapogenin is a compound designated presenegenin having the structure of 2β, 3β, 27-trihydroxy-Δ^{12}-oleanene-23, 28-dioic acid; senegenin and polygalic acid are both artefacts, produced from presenegenin during hydrochloric acid treatment. The roots also contain α-spinasterol, free fatty acids, polygalitol, and a volatile oil, consisting largely of methyl salicylate (B.P.C., 1963, 715; Hoppe,

720; Dugan & de Mayo, *Canad. J. Chem.*, 1965, **43**, 2033; Shimizu & Pelletier, *J. Amer. chem. Soc.*, 1966, **88**, 1544).

Originally it was thought that the senegas available in the Indian markets were of two types: (*i*) foreign senega, derived from *P. senega*, and (*ii*) Indian Senega, consisting of the roots of *P. chinensis*. Later investigations, however, showed that during World War II and in the following years, six commercial varieties of senega could be distinguished in the Indian market: (*i*) foreign senega; (*ii*) Nowshera or Pakistan senega; (*iii*) Delhi senega; (*iv*) Kulu senega; (*v*) Tuticorin Yellow; and (*vi*) Tuticorin Brownish Green. Pakistan senega constituted the bulk of the senegas of the market of pre-partitioned India. It consisted of 3- or 4-year old roots of *Andrachne aspera*. Probably Delhi and Kulu senegas are also obtained from the same plant. It was reported that the source of Tuticorin Yellow was *Glinus oppositifolius* or some allied species (Gupta & Bal, loc. cit.; Qazilbash, *Pharm. J.*, 1949, **163**, 108; Shah & Khanna, *J. sci. industr. Res.*, 1959, **18C**, 121; Ridgway & Rowson, *J. Pharm., Lond.*, 1956, **8**, 915; Shah & Aghara, *Indian J. Pharm.*, 1957, **19**, 97).

P. sibirica Linn. COMMON MILKWORT

Fl. Br. Ind., I, 205; Mukherjee, *Bull. bot. Soc. Beng.*, 1958, **12**, 43; Fyson, I, 35; II, Pl. 23.

A very variable, perennial herb, up to 50 cm. in length, distributed throughout the Himalayas from Kashmir to Assam, up to an altitude of 2,700 m. and in the western ghats from the Nilgiris southwards, mainly, above 1,600 m. Rootstock thick, yellowish brown; leaves orbicular, elliptic-lanceolate, elliptic or oblong, ending in a short curved point; flowers pinkish mauve, purple or blue, occasionally white, in short, erect racemes or occasionally solitary; fruit smooth, broadly-winged capsule.

Some taxonomists consider *P. japonica* Houtt., distributed from Japan to Celebes and Timor, as distinct from *P. sibirica*, distributed from Russia to South China and India. However, the name Japanese senega appears to be attributed to the roots of both these species, which are not distinguished for medicinal purposes (Adema, *Blumea*, 1965–66, **14**, 253; Burkill, II, 1789; Hocking, *Quart. J. Crude Drug Res.*, 1961, **1**, 50).

The leaves are used in spermatorrhoea. The roots are sweetish and somewhat acrid. A decoction of the roots is given as an expectorant in cold and cough and chronic chest diseases. It is also used for diarrhoea and inflammation of urinary bladder and externally for mammary abscesses and carbuncles (Hocking, loc. cit.; Burkill, II, 1789; Kirt. & Basu, I, 235; Atlas med. Pl. U.S.S.R., 210).

P. crotalarioides Buch.-Ham. ex DC. (SANTAL—*Lil kathi, gaighura*; MUNDARI—*Bir-herem da*) is a small perennial herb or undershrub with a woody rootstock found in the temperate Himalayas from Himachal Pradesh eastwards to Sikkim and Assam, ascending up to an altitude of 2,300 m. It is reported to be used for cough and pulmonary catarrh; it also possesses antiseptic properties (Dymock, Warden & Hooper, I, 154; Chopra, 1958, 599).

P. elongata Klein ex Willd. (MAL.—*Periyananka*) is a small herb or undershrub with linear-oblong leaves found in the peninsular India and Bihar. A decoction or the powder of the leaves is reported to be given in biliousness and constipation (Rama Rao, 26).

P. javana DC. is a much-branched undershrub found in the hills of South India, up to 1,500 m. It has been reported to contain a saponin and a blue dye. The roots yield methyl salicylate (Chopra *et al.*, I, 182; Uphof, 290; Wehmer, II, 666).

P. longifolia Poir. syn. *P. leptalea* DC. is a perennial herb found almost throughout the Himalayas up to an altitude of *c.* 1,500 m. and in the hilly parts of Assam, central and southern India; it is also recorded from the Andamans and Nicobars. In Bihar it is used as a galactagogue (Bressers, 7).

POLYGONATUM Mill. (*Liliaceae*)

A genus of perennial herbs distributed in the temperate regions of the northern hemisphere. Sixteen species occur in India.

P. multiflorum All. SOLOMON'S SEAL

D.E.P., VI(1), 316; Fl. Br. Ind., VI, 319; Kirt. & Basu, Pl. 970B.

A perennial herb, 60–90 cm. high, found in western Himalayas from Kashmir to Kumaun, at altitudes of 1,800–2,700 m., and in Manipur. Rhizomes horizontal, with scars of annual stems; leaves oblong-ovate; flowers white, in whorls; berry blue-black; seeds few.

This is a well-known garden plant in temperate regions and includes 3 or 4 varieties, some with double flowers and others with variegated foliage. They are easily propagated by division (Chittenden, III, 1627; Bailey, 1947, III, 2739).

The rhizome is odourless, mucilaginous, sweetish and then bitter and acrid. It is reported to be eaten. When macerated in water, it yields a starchy substance which is used as food. In Lahul, the powdered rhizome is used as soap. In Turkey, the young shoots furnish an excellent vegetable boiled and eaten like asparagus (Wren, 326; Hedrick, 448; Stewart, 234).

The plant is considered diuretic. The rhizome possesses astringent, demulcent and tonic properties. The rhizome causes a considerable lowering and shortening of alimentary hyperglycaemia in rabbits; the antidiabetically active substance is probably a water-soluble non-fermentable sugar. A glucoside and chelidonic acid ($C_7H_4O_6$, m.p. 262° decomp.) have been reported to be present in the plant. The powdered rhizome is used, in Europe, as a poultice for bruises, piles, inflammations, tumours and discolouration of the skin resulting from blows. Combined with other remedies, it may be given in pulmonary complaints, consumption and bleeding of lungs (Hoppe, 719; Kirt. & Basu, IV, 2506–07; *Chem. Abstr.*, 1930, **24**, 4857, 5377; Karrer, 566; Wren, 326).

P. verticillatum All.

D.E.P., VI(1), 316; Fl. Br. Ind., VI, 321.

HINDI—*Mitha dudia.*

PUNJAB—*Shakakul.*

An erect glabrous herb, 60–120 cm. high, found in the temperate Himalayas from Kashmir to Sikkim, at altitudes of 1,800–3,900 m., and in Manipur. Leaves whorled, sessile, linear or lanceolate; flowers white, pinkish white or pale green, in whorled racemes.

The rhizome is eaten as food in the Kurram valley. Roots and rhizome amounting to about 930 kg. are collected annually in Kangra valley. The rhizome is valued as salep, a strength-giving food. The plant possesses diuretic properties. It contains a digitalis glucoside. The plant is considered poisonous by the hill people in the Himalayas (Ahluwalia, *Indian For.*, 1952, **78**, 191; Hoppe, 719).

P. cirrhifolium Royle is a herb, 60–120 cm. high, with whorled, sessile, linear leaves, white, green, purplish or pink flowers, and round, blue-black berry found in the temperate Himalayas from Simla to Bhutan and Manipur at altitudes of 1,200–4,200 m.

The leaves of the plant are eaten as vegetable. The plant is reported to be used as a tonic and vulnerary. The roots are reported to be used for washing purposes (*Bull. bot. Surv. India*, 1960, **2**, 246; Sarin, *Indian For.*, 1967, **93**, 489).

P. oppositifolium Royle, another perennial herb, with an underground rhizome is found in the temperate Himalayas from Nepal eastwards to Sikkim and in Assam, Manipur and Khasi hills, at altitudes of 1,200–2,000 m. It is reported to be eaten as vegetable in Sikkim (Rao Rolla, *Bull. bot. Surv. India*, 1963, **5**, 165).

POLYGONUM Linn. (*Polygonaceae*)

A large genus of herbs, rarely shrubs, distributed almost all over the world, especially in the temperate zones. Nearly 85 species, including a few introduced ones are recorded in India.

This genus is highly variable, composed of several natural species-groups, the taxonomic rankings of which are much in dispute. In recent years, data from cytology, palynology, floral anatomy and chemistry have been utilized to determine their relationships and devise a more rational classification. Some botanists have divided this genus into a number of smaller genera, but their taxonomic groupings are much in dispute and need a more careful study. In the present account, the genus has been dealt with in *sensu lato* (Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 1–119; Graham & Wood, *J. Arnold Arbor.*, 1965, **46**, 106; Chittenden, suppl., 298; Hara, 631).

Several *Polygonum* spp. are worth growing in gardens. They are hardy in general and grow on any soil. Propagation is through seed or divisions (Chittenden, III, 1627).

P. alpinum All.

Fl. Br. Ind., V, 49; Coventry, Ser. II, 97, Pl. XLIX.

A small herb or shrubby plant, up to 1.8 m. high, distributed from Kashmir to Himachal Pradesh at altitudes of 2,100–3,600 m. Rootstocks perennial; leaves lanceolate or linear-lanceolate; flowers white or pale-pink, in terminal thyrsoid panicles, 30 cm. or more long; nuts broadly rhomboid-ovoid.

The herb is eaten either raw or cooked; it is said to taste like rhubarb. Its chemical composition is given in Table 1.

The plant is astringent, and is reported to be used in dysentery of calves and fawns. In the U.S.S.R., the herb is reported to be a commercial source of tannin. The rootstocks contain 16–22 per cent tannin, 14–18 per cent of soluble non-tannins and five per cent sugars. The tannins are the derivatives of leucoanthocyanidins and gallic acid. The flavonoids found in the plant are hyperoside, rutin, avicularin and

quercetin. Caffeic acid and ascorbic acid (in leaves, 831.4 and in flowers, 762.6 mg./100 g.) have also been reported (Hoppe, 722; Howes, 1953, 284; Atlas med. Pl. U.S.S.R., 132; *Chem. Abstr.*, 1962, **56**, 1567).

P. amphibium Linn.

Fl. Br. Ind., V, 34; Blatter, II, 141, Pl. 55, Fig. 3.

A very variable, perennial, amphibious herb, glabrous when aquatic and extremely hairy on land, 30–60 cm. high, distributed from Kashmir to Kumaun, at altitudes of 1,800–2,100 m. Rootstocks woody, creeping; leaves lanceolate, oblong or cordate; flowers bright pink, in terminal spikes; nuts ovoid, shining.

The proximate composition of the herb is given in Table 1. The leaves and rootstocks are used for tanning purposes; they contain 18 and 18–22 per cent tannin respectively. Besides tannin, the herb contains a volatile oil, polygonic acid, malic acid, mucilage, pectin and oxymethylanthraquinone (Wehmer, I, 278; Howes, 1953, 284; Steinmetz, 1957, 881).

The rootstocks are used as a cooling blood purifier, and are substituted for sarsaparilla. They are said to have astringent, tonic, diuretic, depurative and sudorific properties. The fresh rootstocks are used in homoeopathy. The fruits are substituted for pepper (Steinmetz, 1957, 881; Steinmetz, II, 355–56).

P. amplexicaule D. Don

Fl. Br. Ind., V, 32; Blatter II, Pl. 55, Fig. 4 & 5.

UTTAR PRADESH—*Kukar makri, durpa tandar.*

An erect herb, with tufted stems, 30–100 cm. tall, arising from a stout rootstock distributed in the temperate Himalayas from Kashmir to Sikkim, at altitudes of 1,800–4,800 m. Leaves ovate or cordate; flowers pink, deep red or white, in spikes; nuts smooth, shining.

The rootstocks of this herb are collected in the Himachal Pradesh and are sold as the drug *anjubar* (cf. *P. bistorta*). They contain about 16 per cent tannins and 7.8 per cent non-tannins, and are likely to prove useful for tanning purposes. The herb is abundantly found in the moist localities of Jammu and Kashmir and Punjab. It is estimated that about 47,200 kg. of rootstock can be collected annually from these areas for tanning (Ahluwalia, *Indian For.*, 1952, **78**, 188; Sarin & Kapoor, *Bull. reg. Res. Lab., Jammu*, 1962–63, **1**, 136).

The herb is considered a highly palatable fodder. Analysis of the herb from Bugiyal pastures in Uttar Pradesh gave on dry matter basis: crude protein, 16.90; ash, 11.02; calcium, 1.38; phosphorus, 0.17; and magnesium, 0.90% (Joshi, *Indian vet. J.*, 1966, **43**, 1019).

TABLE 1—COMPOSITION OF SOME POLYGONUM SPP.

Polygonum spp.	Moisture %	Protein %	Fat %	Fibre %	Other carbohydrates %	Mineral matter %
P. alpinum[1]	86.4	1.7	0.7	3.9	5.1	2.3
P. amphibium[1]	85.6	2.3	0.4	3.0	6.4	2.3
P. aviculare[1]	81.6	1.9	0.3	3.5	10.2	3.5
P. barbatum[2,*]	..	15.7	2.1	20.7	50.4	11.1
P. bistorta[1]	82.6	3.0	0.8	3.2	7.9	2.4
P. chinense[3,*]	..	11.5	0.9	33.8	40.2	13.6
P. convolvulus[1]	86.1	2.0	0.5	2.4	6.8	2.1
P. dumetorum[1]	83.2	2.3	0.4	3.2	8.6	2.4
P. hydropiper[1]	86.5	1.5	0.2	3.3	6.4	2.1
P. lapathifolium[1]	83.4	2.2	0.7	2.9	9.4	2.4
P. persicaria[1]	85.3	1.6	0.3	3.0	6.4	3.4
P. plebeium[4,†]	83.2	3.2	0.7	2.1	6.9	3.9

[1] Salgues, *Qualit. Plant. Mat. Veg.*, 1961, **8**, 369; [2] Hooper, *Agric. Ledger*, 1904, 72;
[3] Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 210; [4] Nutritive Value of Indian Foods, 54, 90.
* Values are given on dry matter basis.
† Analysis of leaves only.

***P. aviculare** Linn.

D.E.P., VI(1), 317 ; III, 430 ; Fl. Br. Ind., V, 26 : Gage, *Rec. bot. Surv. India,* 1903, **2,** 379 ; Butcher, I, 891, Fig.

Hindi—*Machoti, ban-natia, bannalia, hunraj ;* Beng.—*Machutie.*

Punjab—*Kesru, banduke ;* Kashmir—*Drop.*

A highly variable annual herb, with prostrate stems and branches, up to 60 cm. high, distributed from Kashmir to Kumaun, at altitudes of 1,800–3,600 m. Roots fibrous, very tough, sometimes woody ; leaves elliptic or lanceolate ; flowers small, green, tipped with red or white, in axillary clusters ; nuts ovoid, minutely wrinkled.

The herb is eaten as a vegetable. Composition of the herb is given in Table 1. It is also used as fodder for cattle and sheep. Sheep and goats are said to fatten when fed on this plant. In New South Wales, however, cases of dermatitis and gastric disturbances have been reported amongst sheep and horses. It is reported that the milk from the animals fed on the herb tastes bitter. The herb contains vitamin E, 267 p.p.m. (dry wt. basis) (Webb, *Bull. Coun. sci. industr. Res. Aust.,* No. 232, 1948, 129 ; Nayar, *J. Beng. nat. Hist. Soc.,* 1963-64, **32,** 18 ; *Chem. Abstr.,* 1954, **48,** 3434).

The herb is known as Hunters' Tea or Homerian Tea. It is said to possess astringent, tonic, antipyretic, antiseptic, diuretic, haemostatic and vermifuge properties. It is used in the treatment of diabetes, rheumatism, fever, and external and internal ulcers. A decoction of the herb is given in dysentery, diarrhoea, bronchitis and bleeding piles, and to check profuse menses. Intravenous injections of an aqueous or alcoholic extract of leaves lowered blood pressure in cats, rabbits and dogs. The extract may prove useful as a haemostatic agent. The seeds are aromatic and are powerfully emetic and cathartic (Wehmer, I, 278 ; Kirt. & Basu, III, 2096 ; Watt & Breyer-Brandwijk, 859 ; Hoppe, 721 ; Roi, 113 ; Dymock, Warden & Hooper, III, 149 ; Quisumbing, 257 ; *Chem. Abstr.,* 1943, **37,** 6406 ; 1946, **40,** 5844 ; Uphof, 290 ; Steinmetz, II, 356 ; Crevost & Petelot, *Bull. econ. Indoch.,* 1934, **37,** 736 ; Jacobs & Burlage, 165 ; Tehon, 90).

The herb has been reported to contain tannins (3.5–4.0%), mucilage, sugars, gallic, caffeic, oxalic, silicic, chlorogenic and *p*-coumaric acids, *d*-catechol, leucoanthocyanins, oxymethylanthraquinone (roots 0.35, twigs 0.20 and leaf 0.15%), quercitrin, avicularin and several other flavonoids and polyphenols, which include derivatives of quercetin, kaempferol, esculetin and scopoletin. The flavonoid content of the drug is highest at the start of flowering. The herb contains 0.22 per cent of therapeutically active, water-soluble silicic acid, the concentration of which remains almost constant throughout the growing season ; the total silicic acid, however, varies, the maximum content (1.1%) being at the time of fruit ripening. The herb yields a blue dye similar to indigo (Hoppe, 721 ; Watt & Breyer-Brandwijk, 859–60 ; U.S.D., 1955, 1605 ; *Chem. Abstr.,* 1962, **57,** 4757 ; 1964, **61,** 7362 ; 1965, **63,** 18945).

The herb is reported to have been successfully used in France as a substitute for mulberry for feeding silkworms.

P. barbatum Linn. syn. *P. stagninum* Buch.-Ham. ex Meissn.

D.E.P., VI(1), 317 ; Fl. Br. Ind., V, 37.

Beng.—*Bekh-unjubaz ;* Mar.—*Dhaktasheral ;* Tel.

FIG. 72—POLYGONUM BARBATUM—FLOWERING BRANCH

* This species is considered polymorphic, including perhaps variants resulting from seasonal and environmental factors (Styles, *Watsonia,* 1962, **5,** 177).

Niru ganneru ; TAM.—*Atlari* ; KAN.—*Konde malle* ; MAL.—*Velutta mudela mukku.*

PUNJAB—*Narri* ; MUNDARI—*Garaara, naiara* ; LUSHAI—*Anbong.*

A stout, annual herb, with erect stem, c. 90 cm. high, distributed throughout the hotter parts of India, particularly in wet places, ascending up to an altitude of c. 1,080 m., and also in the Laccadives and the North and South Andamans. Leaves lanceolate or linear-lanceolate ; flowers white or purplish, in small spikes ; nuts shining.

This species includes two varieties, var. *stagninum* Steward and var. *gracile* Steward. The plant is used in curries in parts of West Bengal. The plants growing in dry areas are bitter in taste, while those in wet places are less so. The herb is relished by cattle and goats. Its composition is given in Table 1 (Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 54–55 ; Hooper, *Agric. Ledger*, 1904, 69 : Williamson, 99 ; Fl. Delhi, 306).

The roots are considered astringent and cooling and are reported to be an article of trade in North India. A decoction of the shoots is said to be used as a stimulating wash for ulcers ; the juice acts as a cicatrizant. Powdered leaves are applied to fly-infected wounds of goats. The seeds possess tonic, purgative and emetic properties and are used in colic (Burkill, II, 1791 ; Uphof, 290 ; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 733 ; Kirt. & Basu, III, 2100).

A blue dye similar to indigo is said to be obtained from this herb.

P. bistorta Linn. syn. *P. paleaceum* Wall. ex Hook. f.
BISTORT, SNAKE-ROOT

Fl. Br. Ind., V, 32 ; Gage, *Rec. bot. Surv. India*, 1903, **2**, 390 ; Butcher, I, 895, Fig.

A perennial herb, up to 60 cm. high, with a thick, twisted rootstock, distributed in the Himalayas from Kashmir to Sikkim and in the hills of Assam at altitudes of 2,700–4,500 m. Leaves radical and cauline with winged petioles ; radical leaves ovate-lanceolate, cauline smaller and narrower ; flowers white or pink, in spikes.

The herb is used in stews and soups. It is recommended for use in silage. The rootstocks are reported to be eaten. Table 1 gives the chemical composition of the herb (Uphof, 290 ; Hedrick, 449 ; *Chem. Abstr.*, 1956, **50**, 5101).

This herb is widespread in its distribution and its curled rhizome has been used under the name snakeroot in medicine. It is the *anjubar* of the western Arabs. The rootstocks are somewhat flattened, hard with annual thickenings and traces of rootlets. Liquid extract of the rootstocks and their decoction are used as astringent in diarrhoea, profuse menses, colitis and gingivitis. They possess febrifugal, diuretic, expectorant, haemostatic, and antiseptic properties. The preparations of this herb are substituted for Peruvian Rhatany (*Krameria triandra*) (Dymock, Warden & Hooper, III, 150 ; Medicinal Crude Drugs & Allied Raw Products, 137 ; Steinmetz, I, 83 ; *Chem. Abstr.*, 1944, **38**, 5366 ; Roi, 352 ; Steinmetz, 1957, 883 ; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 734).

The astringent properties of the rootstock are due to the presence of tannin compounds (15–22%, up to 36%). The tannin content undergoes variation during the vegetative period of the plant, the maximum being at the time of fruit bearing. The tannin is of mixed type : catechol, phloroglucinol, gallic acid and phlobaphene have been identified. The best solvent for tannin compounds is 30 per cent alcohol. Methylanthraquinone, calcium oxalate (1.1%), starch (30%), albumin (10%) and traces of emodin are also reported in the rootstock. Tannin is also present in the leaves to the extent of 5–10 per cent. The herb contains caffeic, chlorogenic and protocatechuic acids, and flavonoid glycosides. It is rich in ascorbic acid : flowers contain 746.6, leaves 722.3 and rootstocks 132.2 mg./100 g. (U.S.D., 1955, 1605 ; Hoppe, 723 ; *Chem. Abstr.*, 1961, **55**, 1776 ; 1930, **24**, 5332 ; 1951, **45**, 6863 ; 1960, **54**, 693 ; Atlas med. Pl. U.S.S.R., 132).

P. chinense Linn.

D.E.P., III, 430 ; Fl. Br. Ind., V, 44 ; Gage, *Rec. bot. Surv. India*, 1903, **2**, 408 ; Fyson, II, Pl. 429.

MAR.—*Paral* ; KAN.—*Bilichini ganigalu.*

GARHWAL—*Ameta* ; ASSAM—*Kelnap, kuki* ; LAKHIMPUR—*Madhuri tenga, phiahapa* ; NEPAL—*Kakur thotne.*

A large, rambling or erect herb or undershrub, up to 1.8 m. high, distributed all over India, ascending up to an altitude of c. 3,100 m. in the Himalayas. Leaves very variable, oblong-lanceolate to elliptic ; flowers white or pink or purplish red, in cymose or corymbose inflorescence ; nuts dull black.

This species is widely distributed in the sub-tropical and warm temperate regions of Asia and is highly polymorphic. An extremely wide range of forms is included under this species ; some of them have been described as species or varieties. In the western ghats, it provides a good nectar and pollen source for honeybees during the flowering period (Steward, *Contr.*

FIG. 73—POLYGONUM CHINENSE—FLOWERING PLANT

Gray Herb. Harv., No. 88, 1930, 70 73 : Chaubal & Deodikar, *Indian Bee J.*, 1965, **27**, 13).

The herb is sweet. In Lakhimpur, the plant is used in the preparation of curries. It is relished by cattle and can furnish a good fodder. Table 1 gives the chemical composition of the herb. It is reported to possess tonic, antiscorbutic and vulnerary properties (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 734 : Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**, 370 : Kirt. & Basu, III, 2103).

P. convolvulus Linn. CLIMBING BUCKWHEAT

Fl. Br. Ind., V, 53 ; Gage, *Rec. bot. Surv. India*, 1903, **2**, 417 ; Butcher, I, 903, Fig.

A prostrate or twining herb, up to 3.60 m. in height, distributed from Kashmir to Himachal Pradesh and in Sikkim and the eastern Himalayas. Leaves sagittate-cordate : flowers green with white margins, in axillary clusters and terminal cymes : nuts black, finely furrowed.

The herb is a common weed in cultivated areas in many countries. It is considered a good forage in Iran. Chemical composition of the herb is given in Table 1. The seeds are reported to be used similarly as those of *Fagopyrum esculentum*. They are, however, reported to cause enteritis in animals, due probably to mechanical irritation. The seeds contain: moisture, 12.2 ; protein, 9.1 ; fat, 2.2 ; carbohydrates, 65.7 ; fibre, 8.5 ; and mineral matter, 2.0% (Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 98 ; Jacobs & Burlage, 165 ; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 130 ; Winton & Winton, I, 318).

Rutin, rheum-emodin, an anthraquinone glycoside, myricyl alcohol and calcium bitartrate have been reported in the plant. The rootstocks contain oxymethylanthraquinone (Wehmer, I, 279).

P. glabrum Willd.

D.E.P., VI(1), 318 ; Fl. Br. Ind., V, 34 in part ; Gage, *Rec. bot. Surv. India*, 1903, **2**, 393.

BENG.- *Bihagni* ; TAM.—*Actalaree* ; KAN.—*Niru kanigalu, takta rohita, niru sanne soppu* ; MAL. - *Chuvanna mudela mukku*.

ASSAM—*Larborua, bihlangani, patharua* ; LAKHIMPUR *Patharua bhelagni* ; LUSHAI - *Chakaifu* ; SANTAL *Sauri arak, jioti*.

A stout, erect, annual herb up to 1.5 m. high, distributed throughout India, particularly in marshy

FIG. 74—POLYGONUM GLABRUM—FLOWERING BRANCH

places, ascending up to an altitude of c. 1,900 m.: it occurs gregariously in channel and tank-beds, rooting at nodes. Rootstocks woody; leaves lanceolate or linear-lanceolate; flowers pink or white, in paniculate racemes; nuts brownish black, orbicular-ovoid, polished.

The young shoots and roots are cooked with vegetables; they are pungent, and are used in small quantities. The fruits are parched and made into a kind of *sattu*. The juice of the herb along with other ingredients is given for pneumonia. An infusion of the leaves is given for colic and also prescribed as a febrifuge. The rootstocks are reported to be used for piles, jaundice, debility and consumption. The herb possesses antibacterial activity against *Micrococcus pyogenes* var. *aureus*, *Bacillus subtilis*, *Diplococcus pneumoniae* and *Streptococcus pyogenes* (Hooper, *Agric. Ledger*, 1904, 69; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**, 370; Rama Rao, 335; Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49**, 799).

P. hydropiper Linn. syn. *P. flaccidum* Meissn.
WATER PEPPER, PEPPER-WORT

D.E.P., VI(1), 318; Fl. Br. Ind., V. 39 in part; Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 58–62; Butcher, I, 900, Fig.

BENG.—*Packur mul*, *pani-maricha*.

A glabrous, often glandular, reddish, annual or perennial herb, up to 80 cm. high, distributed throughout India in wet places, ascending up to an altitude of 2,100 m. in the Himalayas. Leaves linear-lanceolate or oblong-lanceolate with resinous cavities; flowers pink or red, in slender racemes; nuts granulate, finely dotted.

The herb has an acrid-peppery taste, and is used as a flavouring. A Japanese variety, var. *laetivirens* Makino, is reported to be cultivated for its acrid leaves which are used as condiment. A type of leaven is prepared in China from the herb admixed with rice flour. Chemical composition of the herb is given in Table 1 (Burkill, II, 1792; *Chem. Abstr.*, 1949, **43**, 7085).

When the herb is eaten by animals, inflammation of the digestive tract occurs resulting in haematuria. Contact with the herb is reported to cause dermatitis in both man and livestock (Burkill, II, 1792; Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 31).

The herb possesses stimulant, diuretic, styptic, emmenagogue and lithontriptic properties; the activity of the root is, however, said to be lost on drying. Liquid extract of the plant is reported to be used as an oral contraceptive. An infusion of the herb is used in uterine disorders and as a haemostatic. In Russia, the extract is employed as a sedative. The bruised leaves and seeds are used as vesicants and are substituted for mustard poultice. The leaves are chewed to relieve toothache. The roots are bitter, and are said to possess stimulant, diuretic, carminative, tonic and anthelmintic properties. Their juice is used as a wash for skin affections. The ether and acid extracts of the herb show antibacterial activity (Hocking, 178; Burkill, II, 1792; Medicinal Crude Drugs & Allied Raw Products, 91; de Laszlo & Henshaw, *Science*, 1954, **119**, 626; Jacobs & Burlage, 166; Steinmetz, II, 357; Quisumbing, 258; Badhwar *et al.*, *Indian J. agric. Sci.*, 1945, **15**, 167; Kirt. & Basu, III, 2101; Nickell, *Econ. Bot.*, 1959, **13**, 302).

The dried powder of the herb is spread on clothes to guard against moths. It is reported to be used as a fish-poison. The greenish mucilaginous juice of the plant kills mosquito larvae, but is not lethal on dilution (Chopra *et al.*, *J. Bombay nat. Hist. Soc.*, 1940–41, **42**, 889).

The herb dyes wool yellow. It contains several flavone compounds (2.0–2.5%), viz. quercetin, quercitrin, kaempferol, rutin, hyperoside (quercetin-3-galactoside), rhamnacin, potassium bisulphate monoester of rhamnacin, persicarin (3-potassium bisulphate ester of *iso*rhamnetin), and persicarin 7-methyl ether (m.p. 212·13°). An acrid essential oil (0.07–0.13%), causing fall in blood pressure and diminishing the tension of non-striated muscles of intestines and uterus, was isolated. Recent work has shown the presence of a new dialdehyde sesquiterpene, tadeonal (polygodial), and its stereoisomers, *iso*tadeonal and confertifolin; tadeonal has the sharp, pungent taste of the plant and is a skin irritant. Occurrence of tannins, vitamin K, a glucoside polygopiperin, an inactive alkaloid, and formic, acetic, valeric, malic and melissic acids has also been reported in the herb. A deep red pigment, idacin, has been identified in the seedlings. The roots contain three per cent tannins and oxymethylanthraquinone [*Chem. Abstr.*, 1955, **49**, 570; 1957, **51**, 5918; 1964, **60**, 13277; 1934, **28**, 1776; Geissman & Hinreiner, *Bot. Rev.*, 1952, **18**, 125; Atlas med. Pl. U.S.S.R., 134; Materiae Rudes Plantarum, II, 456; Barnes & Loder, *Aust. J. Chem.*, 1962, **15**, 322; Hoppe, 722; Wehmer, I, 279; *Japan Sci. Rev., Biol. Sci.*, No. 11, 1960, 178; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 154].

P. lapathifolium Linn.

Fl. Br. Ind., V, 35; Butcher, I, 898, Fig.

A very variable annual, up to 2.5 m. in height, met with from Kashmir to Assam, Orissa and in the Konkan region, ascending up to 2,100 m. Leaves very variable, elliptic-ovate or lanceolate, glabrous or densely tomentose beneath; flowers greenish white, in dense spikes; nuts black, glossy.

Several sub-species, varieties and hybrids of this species have been reported. Though all are not universally accepted, there exists a great genetic diversity combined with plasticity (Simmonds, *J. Ecol.*, 1945–46, **33,** 132).

The chemical composition of the herb is given in Table 1. In Australia, the herb is suspected to cause dermatitis and death in cattle. Alcoholic and aqueous extracts of the plant have shown antibacterial activity. It is reported to have been used in cases of cancer. The herb contains tannins and the rootstock oxymethylanthraquinone (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 130; Nickell, *Econ. Bot.*, 1959, **13,** 302; *Excerpta bot.*, 1968, **13A,** 188; Wehmer, I, 279).

P. minus Huds.

Fl. Br. Ind., V, 36; Butcher, I, 902, Fig.

A slender, erect, glabrous herb, distributed in the hotter parts of India ascending up to *c.* 2,000 m. in the Himalayas. Leaves linear or oblong-lanceolate; flowers minute, pink, in racemes; nuts black, shining.

The leaves are reported to be eaten in curries. The plant contains 2.8 per cent proteins. In Queensland, the herb is suspected of poisoning, causing inflammation of the bladder and gastric tract in calves. A decoction of the leaves is taken for indigestion, and after childbirth. An infusion of the herb is used as fish-poison (Burkill, II, 1792; Terra, *Commun. R. trop. Inst., Amst.*, No. 54e, 1966, 68; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 130).

P. molle D. Don syn. *P. paniculatum* Blume; *P. rude* Meissn.; *P. frondosum* Meissn.

D.E.P., VI(1), 319; Fl. Br. Ind., V, 49–50; Kirt. & Basu, Pl. 810.

Assam–*Kochomah*; Nepal—*Tholne, tuknu, patusua*; Lepcha—*Kandyeo-pam.*

A robust, shrubby perennial, distributed in the central and eastern Himalayas and in the Mishmi hills, at altitudes of 1,200–2,800 m.; it has run wild in the Nilgiris. Leaves elliptic-lanceolate, tomentose or villose beneath; flowers white, in thyrsoid, tomentose panicles; nuts usually in baccate perianth.

The young shoots are pleasantly acidic and eaten like rhubarb. They are stated to be used in the preparation of a jelly. The herb possesses astringent properties and is prescribed in diarrhoea [Kirt. & Basu, III, 2102; Srinivasan, *Rec. bot. Surv. India*, 1959, **17**(2), 30; Banerji, *J. Bombay nat. Hist. Soc.*, 1955–56, **53,** 153].

P. multiflorum Thunb.

Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 96.

A small, perennial, creeping herb, 30 cm. high, native of China and Japan, cultivated in the Indian gardens. Rootstocks tuberous; leaves ovate-cordate; flowers greenish white or pink.

The rootstocks are eaten as food. They are reported to possess tonic and antiscorbutic properties and are used as a black hair-dye. The extract of the rhizome is useful in hyperglycaemia. A preparation of the rootstock is reported to be given to women after childbirth (Hedrick, 449; Burkill, II, 1792–93; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 735; Steward, 98; Hoppe, 722).

The rootstock contains several kinds of chrysophanic acid, emodin, emodin monomethyl ether and chrysophanic acid anthrone in free or combined form. Rhein and rhapontin are sometimes present. A condensation product for sealing cable junctions can be made out of the liquid from the nuts of the plant (*Chem. Abstr.*, 1954, **48,** 7710; 1958, **52,** 12458).

P. nepalense Meissn. syn. *P. alatum* Buch.-Ham. ex Spreng.; *P. punctatum* auct., non Ell.

D.E.P., VI(1), 317; Fl. Br. Ind., V, 41; Peradeniya Manual, No. 7, Pl. XLIII.

Tam.—*Kangany-machan-pillu.*

Punjab—*Sat balon.*

A very variable, much-branched, erect or procumbent, succulent, annual herb, distributed in the hills throughout India, at altitudes of 1,200–3,300 m. Leaves ovate or deltoid-ovate; flowers white or pink, in pedunculate heads; nuts enclosed in perianth at maturity.

The leaves are employed as a local application for swellings. In Ceylon, the herb is grown to provide cover in the tea plantations; it dies under heavy shade or drought, but rapidly regenerates from seeds in the pruned fields. The herb can be eradicated by the use of phenoxy-acetic, O-cresoxy-acetic, and guaiacoxy acetic acids, and 2:4-D (Datta & Banerjee, *Sci. & Cult.*, 1954–55, **20,** 191).

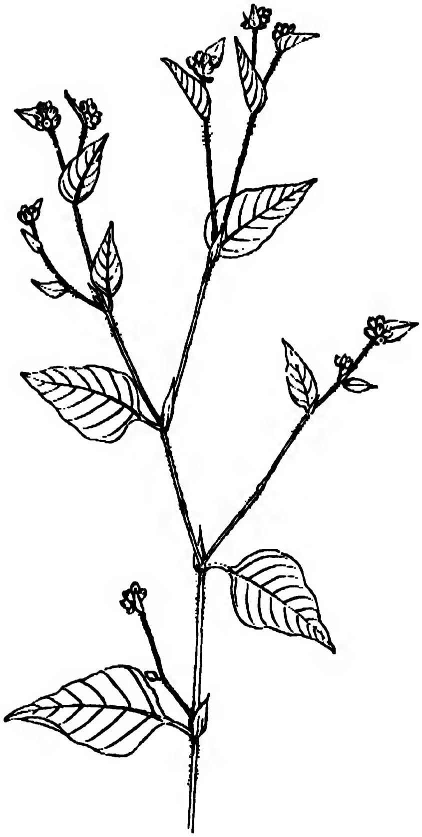


FIG. 75—POLYGONUM NEPALENSE—FLOWERING BRANCH

P. orientale Linn. PRINCE'S FEATHER

Fl. Br. Ind., V, 30; Gage, *Rec. bot. Surv. India*, 1903, **2,** 386; Bailey, 1947, III, Fig. 3104.

BENG.—*Bara pani mirich.*

A tall, hairy, much-branched, annual herb or undershrub, 1–3 m. tall, found in wet places from Kashmir to Assam, and in Madras, ascending up to an altitude of c. 2,000 m. Leaves large, broad-ovate; flowers white, bright pink or rose, in long, dense spikes; nuts flattened, black, shining, orbicular.

The plant is often cultivated and some horticultural forms exist. It is easy to grow, and in some places it runs wild.

The ends of the branches on moistening become thickly glutinous. In Japan and Indo-China, the plant is eaten as pot-herb. Shoots are reported to have a sour taste. The herb is used as a tonic and vulnerary. A concentrated infusion of it is reported to be poisonous to fish. The nuts are prescribed for the treatment of tubercular swellings and flatulence (Burkill, II, 1790; Kirt. & Basu, III, 2103; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 130; Quisumbing, 258).

The leaves yield two flavone glucosides, orientoside (m.p. 259°) and orientin (m.p. 255–57°), which on hydrolysis gave the aglycones apigenin and luteolin, respectively. The presence of alkaloidal material has also been reported. The rootstocks contain oxymethylanthraquinone (*Chem. Abstr.*, 1958, **52,** 17251; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 69; Wehmer, I, 280).

The stem of the plant contains tannic acid, phenolic compounds, and saponins. Extracts of the dried stem stimulated respiration and produced a temporary rise in blood pressure in anaesthetized dogs. They also exert an oxytocic activity on rabbits (*Biol. Abstr.*, 1962, **37,** 268).

P. perfoliatum Linn.

Fl. Br. Ind., V, 46.

KHASI—*Ma-seinthli.*

A prickly climber or rambling shrub, with stem several metres long, distributed in the central and eastern Himalayas from Kumaun to Assam and in the Khasi and Cachar hills, ascending up to an altitude of 2,200 m. Basal portion perennial; leaves peltate, deltoid; flowers white or pink, in short, terminal and axillary racemes; nut black, globose, enclosed in fleshy perianth.

The herb has a pleasant acid taste and is probably wholesome; it is reported to be eaten in Assam. It possesses emollient properties and is used as a cataplasm on tumours. It is reported to be used in softening ivory and bone for easy carving and also to impart different colours (Carter & Carter, *Rec. bot. Surv. India*, 1921, **6,** 370; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 735).

The dried seeds yield 3.3 per cent of a fatty oil, having the following characteristics: $d_4^{20°}$, 0.9250; $n_D^{20°}$, 1.4737; acid val., 2.9; sap. val., 184.6; iod. val., 105.9; and unsapon. matter, 4.9%. The fatty acid composition is as follows: saturated, 22.1; oleic, 38.0; linoleic, 35.7; and linolenic, 4.2% (*Chem. Abstr.*, 1957, **51,** 15971).

P. persicaria Linn. LADY'S THUMB, SMART WEED

Fl. Br. Ind., V, 35; Butcher, I, 897, Fig.

An erect or ascending, annual herb, up to 60 cm. high, sometimes rooting at the nodes, found in Jammu and Kashmir, between altitudes of 2,700 and 4,200 m. Leaves very variable, elliptic-oblong or lanceolate or linear-lanceolate, dotted below;

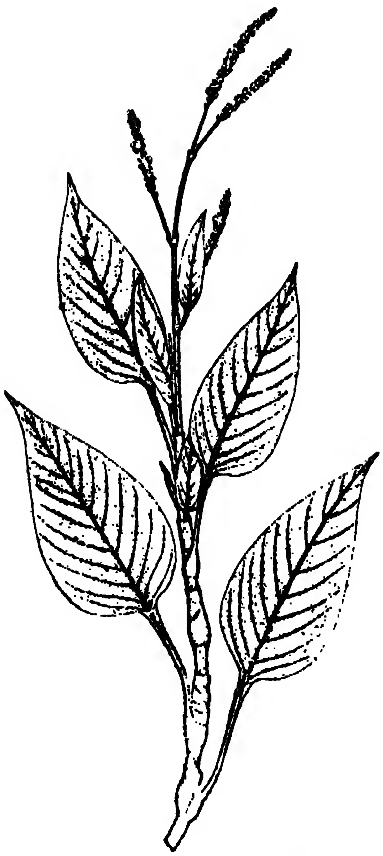


FIG. 76—POLYGONUM ORIENTALE—FLOWERING BRANCH

flowers pink or greenish purple, rarely whitish, in dense spikes; nut blackish brown, trigonous, compressed.

An extremely variable species, distributed in Eurasia, of which many varieties have genetic basis, but none appears to be distinct. The variability is probably similar to that of *P. lapathifolium* (Simmonds, *J. Ecol.*, 1945-46, **33,** 121).

This herb is said to be a good nectar plant in some countries and the yield of nectar is reported to be heavy in wet soils. The honey from it is described as spicy, and very dark, granulating rapidly (Howes, 1945, 178; Pellett, *Econ. Bot.*, 1948, **2,** 187).

The herb is considered to possess astringent, laxative, styptic, antiseptic, vulnerary and lithontriptic properties and is used as a heart stimulant. It is also reported to be useful in colds, fever and asthma. An infusion is useful as a gargle against inflammation of pharynx (Kirt. & Basu, III, 2099; Jacobs & Burlage, 166; Steinmetz, II, 357).

The plant is not usually relished by livestock, though it is occasionally browsed by horses and sheep. Composition of the plant is given in Table 1. Feeding upon this plant is liable to induce abortion in cattle. Cases of dermatitis and poisoning amongst livestock have also been reported. Ingestion of the green parts of the plant produced photosensitization reactions in experimental albino animals. Aqueous extracts of leaves and flowers showed antibacterial activity (Salgues, *Qualit. Plant. Mat. Veg.*, 1961, **8,** 367; Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 32; *Chem. Abstr.*, 1960, **54,** 21605; Nickell, *Econ. Bot.*, 1959, **13,** 302).

The herb yields an essential oil (0.05%) containing acetic and butyric acids and a substance, persicariol, having a camphor-like odour. The flavonoids isolated from the herb include persicarin, hyperoside, avicularin, quercitrin and quercetin. Tannins (1.5%), gallic acid, phlobaphene, mucilage, pectin and ascorbic acid (1%) are also reported. The rootstocks contain oxymethylanthraquinone. The seeds yield 4.8 per cent of a fatty oil (acid val., 1.9; and iod. val., 109) (Atlas med. Pl. U.S.S.R., 136; Gildemeister & Hoffmann, IV, 592; Hoppe, 722; *Chem. Abstr.*, 1942, **36,** 4361).

P. plebeium R. Br.

D.E.P., VI(1), 319; Fl. Br. Ind., V, 27; Gage, *Rec. bot. Surv. India*, 1903, **2,** 383; Kirt. & Basu, Pl. 806.

Beng.—*Chemti sag, dubia sag*; Guj.—*Zinako okhard*; Kan.—*Siranige soppu*; Oriya—*Muthi saga*.

Delhi—*Macheti*; Uttar Pradesh—*Machichi, chotimachhachhie*; Santal—*Raniphul, meree arak*; Lakhimpur—*Banjaluk*.

A very variable, diffusely branched, sub-erect or prostrate undershrub or herb, up to 60 cm. high, often with a woody rootstock, distributed in the moist areas throughout the hotter parts of India, ascending up to c. 2,100 m. in the Himalayas. Leaves variable, linear or linear-oblong to obovate; flowers pinkish or greenish, solitary, axillary or 2-3 together; nuts triquetrous, shining.

The herb is used as a vegetable. It is also eaten by horses. The chemical composition of the herb is given in Table 1. The whole plant yields 11 per cent tannin. The rootstock contains oxymethylanthraquinone. It is reported to be used in bowel complaints. The powdered herb is given for pneumonia (Hooper, *Agric. Ledger*, 1904, 70; Howes, 1953, 284; Wehmer, I, 280; Haines, V, 775; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6,** 369).

P. pulchrum Blume syn. *P. tomentosum* Willd. non Schrank

D.E.P., III, 418; Fl. Br. Ind., V, 30; Fl. trop. E. Africa, Polygonaceae, Fig. 4/3.

A small, thick, pubescent herb, with prostrate stems rooting at the nodes, occurring in wet places in West Bengal, Orissa and the coastal areas of peninsular India; it has also been reported from the North and South Andamans. Rootstock up to 1.2 m. long, often as thick as a finger; leaves very variable in shape and size, usually lanceolate, pubescent; flowers large, white, in racemes; nuts black, shining.

The plant is reported to be eaten by cattle. The leaves are used in salad. In Malaya, the herb is considered to possess tonic and blood-purifying properties. A decoction of it is given to cattle in black-gall sickness. The rootstocks contain 2.5 per cent of an acrid resin, which acts as a cardiac depressant (Burkill, II, 1793; Watt & Breyer-Brandwijk, 860).

P. virginianum Linn.=*Tovara virginiana* (Linn.) Rafin.

Fl. Br. Ind., V, 31; Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 13–14.

A sub-herbaceous perennial, 1.5 m. or more in height, distributed in the temperate Himalayas from Kashmir eastwards and in Assam, at altitudes of 600–3,150 m. Leaves elliptic or elliptic-lanceolate; flowers red, in racemes; fruits ellipsoid, flattened, pale brown, enclosed in persistent perianth.

The herb is stated to possess tonic, astringent, diuretic, demulcent, vulnerary and antispasmodic properties. The ether extracts of stem possess antibacterial activity (Kirt. & Basu, III, 2104; Jacobs & Burlage, 166; Nickell, *Econ. Bot.*, 1959, **13**, 302).

P. viviparum Linn. VIVIPAROUS BISTORT

D.E.P., VI(1), 320; Fl. Br. Ind., V, 31; Kirt. & Basu, Pl. 805c.

PUNJAB -*Maslun, mameche, bajir, bilauri*; KASHMIR—*Masun*.

A small herb, 10–30 cm. high, with a woody rootstock, distributed in the Himalayas from Kashmir to Sikkim, at altitudes of 3,300–4,800 m. Basal leaves long-petioled, linear or linear-oblong, upper leaves sessile; flowers pink or white, in racemes, the lower replaced by bulbils; nuts dark brown, trigonous or biconvex.

According to Hooker, the herb is probably an alpine state of *P. bistorta*. The young leaves and rootstocks are edible. The seeds are considered a delicacy in Russia. The rootstocks are used as a substitute for those of *P. bistorta* as *anjubar*. They are tonic and astringent, and used for diarrhoea, dysentery and haemoptysis. The herb is reported to possess antiseptic properties. A decoction of it makes an excellent gargle for sore throat and spongy gums; it is a good lotion for ulcers (Vykhoditsev & Nikitina, *Trudy biol. Inst., Frunze*, 1947, **1**, 1–26).

P. dumetorum Linn. is a climbing or twining annual herb, 60–90 cm. long, with cordate or lanceolate leaves and greenish or reddish white flowers, distributed in the temperate Himalayas from Kashmir to Kumaun, at altitudes of 1,200–2,700 m. Chemical composition of the herb is given in Table 1. The leaves are used as a laxative. Emodin and rutin have been found in the herb. The rootstocks contain oxymethylanthraquinone (U.S.D., 1955, 1606; Hoppe, 722; Wehmer, I, 279).

P. limbatum Meissn. (SANTAL—*Mangalleta*; MUNDARI -*Marang sukuripota*) is a stout, erect herb with lanceolate leaves and pinkish flowers, met with in swamps and ditches nearly all over India, up to 200 m. The leaves are reported to be eaten as a vegetable (Bressers, 124).

P. macrophyllum D. Don syn. *P. sphaerostachyum* Meissn. is a small herb, with linear or linear-oblong, radical leaves and brilliant-crimson flowers in drooping spikes, distributed in the temperate Himalayas from Garhwal to Sikkim and Bhutan, at altitudes of 3,000–4,800 m. The herb is stated to be a good astringent (Kirt. & Basu, III, 2104).

P. microcephalum D. Don (ASSAM—*Madhu fulong, madu suleng*) is a rigid, tall, erect or decumbent herb, with ovate-lanceolate or oblong leaves and white flowers, distributed in Nepal and Sikkim and in the Khasi, Naga, and Cachar hills, and Assam, ascending up to an altitude of about 2,000 m. In Assam, the young tops are sparingly used as a flavouring for other vegetables.

P. polystachyum Wall. ex Meissn. (PUNJAB—*Amldandi, chuchi, tror*; UTTAR PRADESH—*Sarai*) is a shrubby, perennial herb, with oblong-lanceolate leaves and white or pink flowers in terminal, thyrsoid panicles, distributed in the temperate Himalayas from Kashmir to Mishmi hills at altitudes of 2,100–4,200 m.

The young leaves are eaten as pot-herb; the stalks are consumed either raw after peeling or stewed like rhubarb. The herb is considered a highly palatable fodder. Analysis of the herb from Bugiyal pastures in Uttar Pradesh gave (on dry matter basis): crude protein, 18.4; ash, 9.0; calcium, 1.24; phosphorus,

0.23; and magnesium, 0.9%. The flavones found in the herb are rhamnacin, quercetin, quercitrin, *iso*quercitrin, quercetin diglucoside, probably identical with mercatin, and quercetin-3-mono arabinoside (m.p. 246–47°) (Joshi, *Indian vet. J.*, 1966, **43,** 1019; *Chem. Abstr.*, 1956, **50,** 12039; 1957, **51,** 1848).

P. rumicifolium Royle ex Bab. is a herb, 15–45 cm. high, distributed from Kashmir to Nepal, at altitudes of 1,890–4,200 m. The young parts are acidic and eaten like rhubarb.

P. runcinatum Buch.-Ham. ex D. Don syn. *P. sinuatum* Royle ex Bab. (NEPAL—*Ratna*) is a small, creeping herb, rooting at nodes, with dormant bulbs, found in the Himalayas from Kashmir to Sikkim and in Khasi hills, at altitudes of 1,200–3,100 m. It is reported to be cultivated extensively in Sikkim. The leaves and flowers are eaten raw as well as cooked; they taste like rhubarb (Ghose, *J. Beng. nat. Hist. Soc.*, 1958–59, **30,** 21).

P. sibiricum Laxm. is a dwarf, glabrous herb, with narrowly linear leaves and pink flowers in terminal panicles, found in Kashmir, at altitudes of 3,300–3,600 m. and in Sikkim. The leaves are reported to be eaten.

P. strigosum R. Br. syn. *P. pedunculare* Wall. ex Meissn.; *P. dichotomum* Blume is a sub-erect prickly herb, often rather stout, up to 90 cm. high, with linear-oblong leaves, and pink flowers in panicled racemes, distributed in the Himalayas from Punjab to Assam and southwards in Orissa and South India, ascending up to 1,500 m.

This species is very variable and includes a large number of varieties. The herb is said to be used medicinally by the Chinese. An infusion of the herb is an efficient stupefacient and is used as a fish-poison. In Australia, the herb is reported to cause poisoning in livestock (Steward, *Contr. Gray Herb. Harv.*, No. 88, 1930, 88; Burkill, II, 1792; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 131).

P. tortuosum D. Don (PUNJAB—*Niala*) is a much-branched, low shrub, found in the western Himalayas from Garhwal westwards to Ladakh, at altitudes of 2,700–5,000 m. It is browsed by goats and yaks. It has been reported to be used as a yellow dye.

Polypodium — *see* **Drynaria, Pleopeltis, Polystichum**

POLYPOGON Desf. (*Gramineae*)

A genus of annual or perennial grasses found in tropical, sub-tropical and temperate regions. Two species are recorded in India.

P. fugax Nees ex Steud. syn. *P. littoralis* Sm. var. *higegaweri* Hook. f.

Fl. Br. Ind., VII, 246; Fl. Assam, V, 155.

An annual tufted grass found in the temperate Himalayas from Kashmir to Bhutan up to an elevation of 1,200–3,000 m. and in the Naga hills above 1,500 m. Leaves very scabrid, 6–10 cm. long and 3–5 mm. broad; inflorescence a spike-like panicle, with small awned spikelets.

Although *P. fugax* does not usually occur in the plains in India, the seeds are sometimes carried down by the rivers and are found growing on sand banks and in gravelly river beds (Haines, V, 976; Prain, II, 1212).

The grass is grazed by cattle. Analysis of the grass from Jammu gave (on dry basis): protein, 7.0; ether extr., 1.6; carbohydrates, 42.0; crude fibre, 29.3; mineral matter, 18.4; calcium (CaO), 1.2; and phosphorus (P_2O_5), 0.4% (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26,** 415).

P. monspeliensis Desf. RABBIT-FOOT GRASS, ANNUAL BEARD-GRASS

Fl. Br. Ind., VII, 245 in part; Blatter & McCann, 207, Pl. 137.

BOMBAY—*Chitra, malhar.*

An annual tufted grass found almost throughout India from the Himalayas down to Kerala up to a height of 2,700 m. Leaves flat, linear, scabrid; panicle spike-like, with spikelets 2.0–2.5 mm. long, awn up to 8 mm. long; caryopsis about 1.5 mm. long.

The grass becomes very bushy in moist places and is said to afford rich feeding for grazing animals (Bor, 1960, 403).

An analysis of the grass from Jammu gave (on dry basis): protein, 11.8; ether extr., 1.3; carbohydrates, 38.0; crude fibre, 24.9; mineral matter, 21.9; calcium (CaO), 1.2; and phosphorus (P_2O_5), 0.9% (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26,** 415).

This species is occasionally cultivated in gardens on account of its attractive silky panicles (Hubbard, 285).

POLYSCIAS Forst. & Forst. f. (*Araliaceae*)

A genus of shrubs and trees distributed in the tropics of the Old World, particularly the Pacific Islands. One species occurs wild in India and three exotics are grown for ornament.

Polyscias are easily propagated by cuttings from mature wood (Bailey & Bailey, 581).

P. fruticosa (Linn.) Harms syn. *Nothopanax fruticosum* Miq.; *Panax fruticosum* Linn.

Fl. Br. Ind., II, 725; Bailey, 1947, III, 2745, Fig. 3113.

An aromatic shrub, up to 2.5 m. high, cultivated in gardens all over India for its ornamental variegated foliage: also grown in pots and for hedges. Leaves up to 30 cm. long, 2–3 pinnate: leaflets very variable, narrow-ovate to oblanceolate, sometimes laciniate, finely or deeply bristle-serrate; flowers yellow or bronze-green, in umbellate heads; fruits compressed, broadly ovoid, *c.* 4 cm. long.

The leaves are used as a flavouring; they are also eaten after boiling. The root tastes like parsley. The plant is said to possess astringent properties; it is used in fevers. The leaves and roots are diuretic: their decoction is given for the treatment of stone, gravel and dysuria. The powdered leaves are mixed with salt and used as a vulnerary (Burkill, II, 1563, 1795; Brown, 1946, III, 170; Quisumbing, 678; Kirt. & Basu, II, 1234).

P. pinnata Forst. & Forst. f. is a shrub, native of the Pacific Islands, cultivated for ornament in various horticultural forms and often grown as a hedge. The species has been introduced into the Indian Botanic Garden, Calcutta. The leaves are rubbed on the gums prior to extracting the teeth, presumably with the idea of benumbing the nerves (Stone, *Taxon,* 1965, **14,** 281).

P. scutellaria (Burm. f.) F.R. Fosberg syn. *Nothopanax scutellarium* Merrill; *N. cochleatum* Miq.; *Panax cochleatum* DC. is a large shrub, 1.5–3.5 m. high, commonly grown in pots and gardens for its ornamental foliage. Leaves commonly unifoliolate or with 2–5 rounded or cordate leaflets, but sometimes white or yellow variegated, saucer-shaped.

The young leaves are boiled and eaten as a vegetable. They are used for dressing ulcers. In Java, a poultice of the leaves is applied to the scalp to prevent baldness. The roots are diuretic (Burkill, II, 1563; Quisumbing, 678).

POLYSTICHUM Roth (*Polypodiaceae*)

Beddome, Indian Ferns, 201.

A large genus of evergreen, terrestrial or occasionally epiphytic ferns distributed in the warm parts of the world. About 24 species occur in India, mostly in the Himalayas.

Several species of *Polystichum* are grown for ornament. Many of these are hardy and thrive best in well-drained, sandy loam. They are propagated either by spores or divisions (Bailey, 1947, II, 1215; Chittenden, III, 1638).

P. aculeatum (Linn.) Roth syn. *Polypodium aculeatum* Linn. (Kumaun—*Kuthiore, kuthurka*), commonly known as Hard- or Prickly-Shield Fern, is a hardy, very variable, tufted, terrestrial fern found in the hills almost throughout India, some varieties ascending to an altitude of about 4,000 m. Several horticultural varieties are grown in green houses and in the open for their elegance. The fronds attain a large size (up to 1.0 m. long) and are used for the preparation of a curry (Bailey, 1949, 87; Bhargava, *J. Bombay nat. Hist. Soc.*, 1959, **56,** 26).

Polytoca — *see* **Chionachne, Trilobachne**

POMADERRIS Labill. (*Rhamnaceae*)

Bailey, 1947, III, 2750; Fyson, I, 121; II, Pl. 94.

A small genus of shrubs native to Australia, New Zealand and New Caledonia, sometimes planted for ornament in warm regions. Three species are reported to be grown in India.

P. apetala Labill., a highly tomentose shrub or small tree with thick lanceolate leaves and very attractive white, apetalous flowers, borne in panicles, 5–8 cm. long, is reported from Nilgiris and Darjeeling. It is considered a useful tree for fodder. The leaves are said to be eaten with avidity by pasture animals (Krishnamurthi, 223; Biswas, *Rec. bot. Surv. India*, 1940, **5,** 369; *Jt Publ. imp. agric. Bur.*, No. 10, 1947, 48).

P. lanigera Sims and *P. racemosa* Hook. are two other species introduced into India, the former reported from Nilgiris and Kodaikanal hills and the latter from the Lloyd Botanic Garden, Darjeeling (Pallithanam, *J. Bombay nat. Hist. Soc.*, 1956–57, **54,** 835; Biswas, loc. cit.).

Pomegranate — *see* **Punica**

POMETIA Forst. & Forst. f. (*Sapindaceae*)

A small genus of trees distributed in the Indo-Malaysian region and the Pacific Islands. One species occurs in India.

P. pinnata Forst. & Forst. f. syn. *P. tomentosa* Kurz

Kasai Tree

D.E.P., VI(1), 320; Fl. Br. Ind., I, 691 in part.

Andamans—*Thitkandu.*

An evergreen, buttressed tree, up to 47 m. high and 3 m. in girth, with a dense shady crown found

commonly along the streams in the Andamans. Bark reddish brown, exfoliating in small, thick flakes; leaves paripinnate, up to 90 cm. long: leaflets 8–20, orbicular to oblong-lanceolate, increasing in size towards the tip; flowers polygamous, small, yellowish green or brownish, in large pendulous panicles; fruits ellipsoid or sub-globose, 1.2–5.0 cm. diam., smooth, purple, deep red or brown, changing to black; seeds red-brown, enclosed in a white, pulpy arillode.

This species is extremely variable, and is still in the process of differentiation. Eight forms have taxonomically been recognized, of which two, f. *glabra* (Blume) Jacobs and f. *tomentosa* (Blume) Jacobs, have been recorded from the Andamans. Besides, several unidentified paramorphs have also been differentiated (Jacobs, *Reinwardtia*, 1961–64, **6**, 109).

The Kasai tree is good for ornamental purposes. In Malaya, its native country, it thrives on sandy alluvium, particularly on the riverside and withstands periodical inundations. It is propagated through seed (Mitchell, *Malay. For.*, 1964, **27**, 136).

Sapwood is pale, gradually merging into purplish or reddish brown heartwood. The latter is close-grained, rather fine-textured, moderately hard, strong, tough, flexible and heavy (wt., 673–881 kg./cu.m.). It is difficult to season and is liable to shrink and warp badly unless stacks are suitably weighted. It is durable under cover, but only moderately so in exposed situations and in contact with the ground. It is easy to work, bends well when steamed, and takes fine polish. Analysis of the wood (from Philippines) gave: cellulose, 43.97; lignin, 37.29; and ash, 1.36%. The wood, after careful seasoning, is used for tea-boxes and sleepers. In the Philippines, it is used for beams, joints, rafters, masts and spars, flooring and other interior construction, furniture, cabinet-work, agricultural implements, tool handles, boat making and cooperage. It is also used as fuel in the Andamans. The timber is attacked by beetle borers and fungi. Probably it contains triterpenes [Browne, 319; Howard, 513; Burkill, II, 1797; Yenko *et al.*, *Philipp. J. Sci.*, 1934, **55**, 1; Desch, 1954, 533–35; Lewis, 118–19; Parkinson, 136; Mathur & Balwant Singh, *Indian For. Bull.*, *N.S.*, No. 171(7), 1959, 51; Sujan Singh *et al.*, *Indian For.*, 1961, **87**, 248; Simes *et al.*, *Bull. sci. industr. Res. Org. Aust.*, No. 281, 1959, 11].

F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 77—POMETIA PINNATA—TRANSVERSE SECTION OF WOOD (×10)

The arillodes are sometimes eaten; they are juicy and sweet and possess pleasant flavour. Seeds are oily, and are consumed boiled or roasted. A decoction of the leaves and bark is used in a bath for fever. In Java, the bark is applied to festering sores (Uphof, 292; Burkill, II, 1797; Jacobs, loc. cit.).

PONCIRUS Rafin. (*Rutaceae*)

A monotypic genus, native of central and northern China, formerly included under *Citrus*.

P. trifoliata Rafin. syn. *Citrus trifoliata* Linn.

TRIFOLIATE ORANGE

Swingle in Webber & Batchelor, I, 367, Fig. 60; Hume, 1957, 28, Fig. 35–37.

A small densely branched tree of rather upright habit, 3.5–4.5 m. high, with stout stiff thorns and trifoliate, deciduous leaves; flowers large, white; fruit very fragrant, light orange, 3.7–5.0 cm. diam., rough, densely covered with fine downy hairs.

The trifoliate orange is said to have been an early introduction to Assam. It differs from all other tropical or sub-tropical citrus fruit trees in having penetrated far into the temperate zone in north-eastern Asia and in so doing has become hardy and frost resistant. As a commercial fruit, the trifoliate orange is worthless, but it is, however, valuable as a hedge or ornamental plant, as a stock on which to

work citrus fruit varieties and as a parent in hybridization (Sampson, *Kew Bull. Addl Ser.*, XII, 1936. 145 ; Swingle in Webber & Batchelor, I, 367 ; Hume, 1957, 28).

Almost all kinds of citrus fruits grow readily on this stock, but are somewhat dwarfed and forced into early bearing. Of all the stocks for citrus trees, it is the hardiest and imparts to the scion some of its hardiness and resistance to heat and cold, though it may not be advisable to use it as a stock in regions free of frost. It is said to be immune to *Phytophthora* root-rot and able to thrive in soils too moist for other rootstocks. Fruits produced by trees grown on this stock are usually smaller in size than on other stocks, but are very attractive and of fine quality ; the trees are very precocious and prolific. In China, the trifoliate orange is said to be preferred as rootstock for a fruit very similar to our Indian *Santara*. In Japan and U.S.A., it has been used extensively as rootstock for high grade Satsuma oranges, and for grape fruit (*Citrus paradisi*), tangerine (*C. reticulata*), kumquat (*Fortunella* sp.) and others. Its performance as a rootstock for the sweet orange under Saharanpur conditions was not as encouraging as that of *Karna khatta* (*Citrus karna*) which is the most widely used stock in North India (Hume, 1957, 168–71 ; *Plant Breed. Abstr.*, 1954, **24,** 275 ; Hayes, 203 ; Singh, *Indian J. Hort.*, 1963, **20,** 88 ; Chakravarthy, *Sci. & Cult.*, 1964, **30,** 99).

The trifoliate orange has been crossed with many members of the *Citrus* group with the object of obtaining hybrids that would resist frost. These hybrids, named Citranges, have proved to be vigorous growers that withstand temperatures fatal to ordinary oranges, but in quality the fruits are not so good as the sweet oranges. It is possible that further hybridization may yield a race of hardy edible fruits. The citranges have also proved valuable as vigorous, hardy, disease resistant rootstocks for other citrus fruit types. They have also been crossed with the kumquats to produce Citrangequats, some of which have become well known in U.S.A. (Hume, 1957, 29–32 : Swingle in Webber & Batchelor, I, 369).

Two flavonone glycosides, viz. poncirin ($C_{28}H_{34}O_{4}$. $3H_2O$, m.p. 210–11°) and naringin ($C_{27}H_{32}O_{14}$, m.p. 82°), have been isolated from the leaves, flowers and the fruit peel. Poncirin is present also in the fruit flesh. Both the immature and the fully ripe fruits, sliced and dried, are said to be used in Chinese medical practice. A syrup can be made from the juice of the fruit which can be used for flavouring. The peel can be candied after treatment with brine and softening by boiling ; it is said to make excellent spicy flavouring for cakes. The residue after removing the peel yields about 5.75 per cent pectin from which a stiff jelly with a bitterish flavour can be prepared (Swingle in Webber & Batchelor, I, 370 : McIlroy, 40 : *Chem. Abstr.*, 1957, **51,** 6788).

PONGAMIA Vent. (*Leguminosae ; Papilionaceae*)

A small genus of trees represented in India by *P. pinnata*, distributed from Seychelles and India to northern Australia and Fiji in the east. The seeds of *P. pinnata* yield a useful oil.

P. pinnata Pierre syn. *P. glabra* Vent.

PONGAM OIL TREE, KARANJ, INDIAN BEECH

D.E.P., VI(1), 322 : Fl. Br. Ind., II, 240 : Thothathri, *Bull. bot. Surv. India*, 1961, **3,** 417.

HINDI, BENG., MAR. & GUJ.—*Karanj, karanja ;* TEL.—*Gaanuga, pungu ;* TAM. *Ponga, pongam ;* KAN.—*Honge ;* MAL.—*Pungu, punnu ;* ORIYA—*Koranjo.*

PUNJAB & KUMAUN—*Sukhchein, karanj, paphri ;* ASSAM—*Karchaw.*

A medium-sized glabrous tree, with a short bole and spreading crown, up to 18 m. high or some-

FIG. 78—PONGAMIA PINNATA—FLOWERING BRANCH AND FRUITS

times even more and c. 1.5 m. in girth, found almost throughout India, up to an altitude of 1,200 m. and distributed further eastwards, chiefly in the littoral regions of south-eastern Asia and Australia. Bark greyish green or brown, smooth or covered with tubercles; leaves imparipinnate: leaflets 5-7, ovate or elliptic; flowers lilac or white tinged with pink or violet, fragrant, in axillary racemes; pods compressed, woody, indehiscent, yellowish grey when ripe, varying in size and shape, elliptic to obliquely oblong, 4.0–7.5 cm. long and 1.7–3.2 cm. broad, with a short curved beak; seeds usually 1, rarely 2, elliptical or reniform, 1.7–2.0 cm. long and 1.2–1.8 cm. broad, wrinkled, with reddish brown leathery testa.

This species includes perplexingly variable forms, sometimes classified as different varieties or species. Recently a comparative study of the chemical components of the various parts of the Indian and Australian materials suggested that they may be distinct (Prain, *J. Asiat. Soc. Beng.*, 1897, **66**, pt 2, No. 2, 347; Khanna & Seshadri, *Curr. Sci.*, 1964, **33**, 644).

The tree is considered to be a native of western ghats and is chiefly found along the banks of streams and rivers or near sea coast in beach and tidal forests. It is not exacting in its soil and climatic requirements and grows in dry places far in the interior, up to an elevation of 1,000 m. It is often grown as a roadside avenue tree nearly all over India. It resists drought well, is moderately frost-hardy and highly tolerant of salinity. It is a shade-bearer and is considered to be a good tree for planting in pastures, as grass grows well in its shade. The tree is used for afforestation, especially in water sheds, in the drier parts of the country (Troup, I, 331–32; Dawson, *Mysore agric. J.*, 1960, **35**, 109; Burkill, II, 1798).

Natural reproduction is through seed or by root suckers. The seeds are said to retain viability for a year. Artificial regeneration is carried out through direct sowings or transplanting one-year old seedlings raised in nursery. Root or shoot cuttings can also be used for this purpose. It is a good coppicer, and is regarded as a fast-growing species. In West Bengal, a rotation of 30 years is considered suitable for fuel plantations. In South India, the tree is often pollarded for fodder or for green manuring purposes. The tree is attacked by a large number of insects and a few fungi. It is a host for the lac insect [Troup, I, 331–32; Mathauda, *Indian For.*, 1955, **81**, 563; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 51; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 284; Burkill, II, 1799].

The tree starts bearing at the age of 4–7 years. The fruits come to harvest at different periods of the year in different parts of the country, but the harvest season extends in general from November–December to May–June. The pods are collected and the shells removed by hand. The yield of seed is said to range from 9 to 90 kg. per tree. No organized collection of seed is undertaken and a large part of the produce is not collected. The quantity actually collected in different parts of the country varies from about 75 per cent of the potential production as in Mysore, to a low figure of just about 2 per cent as in West Bengal. The total quantity available for collection in the country is estimated at about 97,000 tonnes against the actual collection of only 11,500 tonnes (Troup, I, 331; Sankaran, *Indian Oilseeds J.*, 1956–57, **1**, 224, 347; 1959, **3**, 179; Bhushan, ibid., 1960, **4**, 30; Narayanan, ibid., 1960, **4**, 93; Patel & Yawalkar, ibid., 1963, **7**, 148).

FIG. 79—PONGAMIA PINNATA—PODS AND SEEDS

UTILIZATION AND COMPOSITION

Seeds—The mature seed (av. wt., *c.* 1 g.) consists of about five per cent of shell and 95 per cent of an oleaginous kernel. Analysis of a sample of air-dried kernels (from Waltair) gave the following values: moisture, 19.0; fatty oil, 27.5; protein, 17.4; starch, 6.6; crude fibre, 7.3; and ash, 2.4%. The seeds contain a mucilage (13.5%), traces of an essential oil, and a complex amino acid named glabrin ($C_{21}H_{12}O_{12}N_3$, m.p. 290° decomp.). Four furanoflavones, karanjin ($C_{18}H_{12}O_4$, m.p. 158.5°), pongapin ($C_{19}H_{12}O_6$, m.p. 190–91°), kanjone ($C_{18}H_{12}O_4$, m.p. 191°), and pongaglabrone ($C_{18}H_{10}O_5 \cdot \frac{1}{2}H_2O$, m.p. 233°), and a diketone pongamol ($C_{18}H_{14}O_4$, m.p. 128–29°) have been isolated from the Indian seeds. Seeds from Australia contained only pongapin. Karanjin and pongamol, which are associated with non-glyceride portion of the oil and have a bitter taste, are the major flavones of the seeds; other flavones occur as minor components. The presence of a hypotensive principle and a substance producing marked uterine contractions has been reported. Seeds and immature pods from Australia gave positive tests for the presence of alkaloids [Rao *et al., Proc. Indian Acad. Sci.*, 1939, **10A,** 65; Rao & Rao, ibid., 1941, **14A,** 123; Sinha, *J. Instn Chem. India*, 1960, **32,** 70; Chopra, 1958, 389; Rangaswami & Seshadri, *Proc. Indian Acad. Sci.*, 1942, **15A,** 417; Narayanaswamy *et al., J. chem. Soc.*, 1954, 1871; Aneja *et al.*, ibid., 1963, 163; Khanna & Seshadri, *Tetrahedron*, 1963, **19,** 219; *Curr. Sci.*, 1964, **33,** 644; Bhatnagar *et al., J. sci. industr. Res.*, 1961, **20A**(8), suppl., 1; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 55; ibid., No. 241, 1949, 31].

The seeds are mainly valued for the oil obtained from them which has many industrial and medicinal uses. Powdered seed is valued as a febrifuge and tonic and used also in bronchitis and whooping cough. The powder of the rind of the pod is also similarly used. The seeds crushed to paste are used for leprous sores, skin diseases and painful rheumatic joints. The seeds are reported to be used as a fish-poison (Kirt. & Basu, I, 830; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 4, 1960, 8; Nadkarni, I, 1004; Burkill, II, 1798).

Pongam oil—The seeds contain 27–39 per cent of a fatty oil which is used for leather dressing, soap making, lubrication, illumination, and for medicinal purposes. The seeds may be crushed for oil entirely in the mills as in Maharashtra or to some extent in village crushers also as in Andhra Pradesh and Mysore. The yield of oil varies according to the methods of extraction; in general, it is 24.0–27.5 per cent from the expellers and 18–22 per cent from village crushers (Eckey, 521; Sankaran, *Indian Oilseeds J.*, 1956–57, **1,** 221; Narayanan, loc. cit.).

Crude pongam oil has a yellowish orange to brown colour which darkens on storage. It possesses a disagreeable odour and a bitter taste, and has the following characteristics: sp. gr.^{30}, 0.9273; $n^{30°}$, 1.4736; sap. val., 181.5; iod. val., 89.1; acid val., 6.3; acet. val., 20.9; and unsapon. matter, 4.2%. The colouring and odorous constituents of the oil are not easily removed by the conventional methods of purification. A process for the purification of the oil by cold extraction with alcohol and subsequent alkali refining and bleaching has been patented; the final product is obtained in a yield of 91 per cent. Alcohol percolation through the seeds prior to pressing has also been suggested. A pale and almost neutral product (acid val., 0.1; colour, 7.6 Y+0.7 R) can be obtained by treating the crude oil with sodium chlorite and then with alcoholic caustic soda in three stages in concentrations of 0.3, 0.1 and 0.1 per cent (Vidyarthi, *Indian Soap J.*, 1951–52, **17,** 54; Mitra, Indian Pat., No. 47802, 1954; Nandanwar *et al.*, *Indian Oil & Soap J.*, 1963–64, **29,** 48; Rebello & Shitolle, *J. sci. industr. Res.*, 1961, **20D,** 179).

Indian Standard Specifications for pongam oil are as follows: moisture and insoluble impurities, $\not>$0.25%; colour (on the Lovibond scale, Y+5 R), $\not>$40; sp. gr.$\frac{30°}{30°}$, 0.925–0.940; $n^{40°}$, 1.4734–1.4790; acid val., $\not>$20; sap. val., 185–95; iod. val. (Wijs), 80–90; unsapon. matter, $\not>$3.0%; and titre, $\not<$31°; the filtered sample kept at 30° for 24 hours shall show no turbidity (IS: 3492–1965).

The oil resembles groundnut oil in composition. The fatty acid composition of the oil shows the following ranges of values: palmitic, 3.7–7.9; stearic, 2.4–8.9; arachidic, 2.2–4.7; behenic, 4.2–5.3; lignoceric, 1.1–3.5; oleic, 44.5–71.3; linoleic, 10.8–18.3; and eicosenoic, 9.5–12.4%. Some investigators have variously recorded the presence of myristic, dihydroxystearic, cerotic, linolenic, and traces of docosenoic and tetracosenoic acids. The unsaponifiable matter contains β-sitosterol (*Indian Oil & Soap J.*, 1964–65, **30,** 121; Mehta & Meshramkar, *Indian J. appl. Chem.*, 1960, **23,** 23; Desai *et al., J. Indian Inst. Sci.*, 1923, **6,** 93; Gupta & Mitra, *J. Indian chem. Soc.*, 1953, **30,** 781; Pathak & Dey, *J. chem. Soc.*, 1957, 1917; Sinha, *Indian J. appl. Chem.*, 1959, **22,** 86).

The non-fatty components of the oil include karanjin and pongamol. Karanjin slowly separates

from the oil on standing: older samples of the oil, therefore, contain lesser amounts of karanjin. Its concentration in the oil also depends considerably upon factors like the place of origin and season of collection of seeds. The pongamol content of the oil does not show much variation. Yields of up to 1.25 per cent of karanjin and 0.85 per cent of pongamol have been obtained from the oil (Rao *et al.*, *Proc. Indian Acad. Sci.*, 1939, **10A**, 65; Rao & Seshadri, *Curr. Sci.*, 1940, **9**, 76; Rangaswamy & Seshadri, *Indian J. Pharm.*, 1941, **3**, 3; Jatkar & Mattoo, *J. Indian chem. Soc., industr. Edn*, 1954, **17**, 39).

The main use of pongam oil is in the tanning industry for the dressing of E.I. leathers. A process has been developed for the preparation of sulphated pongam oil which can be used for making fat liquors suitable for the leather industry. The oil finds use to a certain extent in the preparation of washing soaps and candles. It is more suitable for this purpose after refining, since crude oil produces a soap with objectionable colour and odour. The purified oil can be used up to the extent of 25 per cent in the soapstock without affecting the quality of the soap. Partially hydrogenated pongam oil can replace hardened groundnut oil in laundry soaps [Kishore *et al.*, *Bull. cent. Leath. Res. Inst., Madras*, 1955–56, **2**, 9; Kishore & Nayudamma, Indian Pat., No. 62348, 1959; Sethi, *Indian Oil & Soap J.*, 1964 65, **30**, 68; ibid., 1964-65, **30**, 121; Patnaik, *Oils & Oilseeds J.*, 1950–51, **3**(12), 16].

The oil can be used after neutralization as a lubricant for heavy lathes, chains, bearings of small gas engines, enclosed gears and heavy engines. It has also been tried as a fuel in diesel engines; it showed good break thermal efficiency. The oil is used in the villages for illumination purposes (Thiagarajan & Srikantan, *J. Indian chem. Soc., industr. Edn*, 1950, **13**, 163, 201, 210, 219, 227; Chowdhury *et al.*, *Gas Oil Pwr*, 1942, **37**, 80).

The oil is highly esteemed for medicinal purposes. It is applied in scabies, herpes, leucoderma and other cutaneous diseases. Internally, it has sometimes been used as stomachic and cholagogue in cases of dyspepsia with sluggish liver. Mixed with lime or lemon juice, it has been reported to be useful in the treatment of rheumatism (Chopra, 1958, 338; Kirt. & Basu, I, 830).

Karanjin is the active principle responsible for the curative effect of the oil in skin diseases. Clinical experiments indicate that it is free from the highly irritating and inflammatory effects of coumarin compounds and its application in solution with other vegetable oils such as coconut, sesame or groundnut oil is reported to be better than when incorporated in a paraffin base (Seshadri & Sood, *Curr. Sci.*, 1963, **32**, 195; Rangaswami & Seshadri, *Indian J. Pharm.*, 1940, **2**, 83).

The oil and its active component karanjin possess insecticidal and antibacterial properties. Two per cent pongam oil-resin soap spray is reported to be effective against the nymph and adult stages of the green bug of coffee. Karanjin is highly toxic to fish; pongamol exhibits comparatively mild toxicity. Alcoholic extracts of oil showed activity against both Gram-positive and Gram-negative organisms such as *Micrococcus pyogenes* var. *aureus*, *M. pyogenes* var. *albus*, *M. pyogenes* var. *citreus*, *Bacillus subtilis*, *Corynibacterium diphtheriae*, *Salmonella typhosa*, *S. paratyphi* A and B, and *Escherichia coli*. Karanjin (in dilutions of 10^{-5}) suppressed the growth of *Mycobacterium tuberculosis* $H_{37}Rv$. Conflicting results are reported regarding the antibiotic activity of the oil and its extracts when determined by different tests (Osmani & Naidu, *Sci. & Cult.*, 1956–57, **22**, 235; *Chem. Abstr.*, 1934, **28**, 6515; Rangaswami & Seshadri, *Indian J. Pharm.*, 1941, **3**, 3; Patel & Trivedi, *Indian J. med. Res.*, 1962, **50**, 218; Bhat *et al.*, *Indian Oilseeds J.*, 1956 57, **1**, 298; Ramaswamy & Sirsi, *Indian J. Pharm.*, 1960, **22**, 34; Jambotkar *et al.*, ibid., 1962, **24**, 154).

Seed cake—The cake left after expression of oil has a bitter taste and is unsuitable for feeding livestock. It has a high nitrogen content and is mostly used as a manure. In Mysore, it is sought after by sugarcane growers and gardeners, as it repels red ants. The cake is also valued as manure for coffee and is also reported to reduce the incidence of root-knot of tomato caused by *Meloidogyne javanica* (Treub.) Chitwood. It is found to nitrify the soil considerably; de-oiling has no influence on nitrification. A sample of the expeller cake from Uttar Pradesh showed the following chemical composition: moisture, 9.7; oil, 7.8; protein, 31.9; carbohydrates, 39.8; fibre, 3.7; and ash, 7.1%. The manurial value of the cake is as follows: nitrogen, 5.1; phosphorus (P_2O_5), 1.1; sodium (Na_2O), 0.8; and potassium (K_2O), 1.3%. The seed cake contains glabrin and free arachidic, lignoceric and behenic acids [Eckey, 521; Iyengar, *Mysore agric. J.*, 1956, **31**, 5; Cameron, 98; Singh, *FAO Pl. Prot. Bull.*, 1965, **13**(2), 35; Naik *et al.*, *Poona agric. Coll. Mag.*, 1960–61, **51**(3 & 4), 27; Om Prakash *et al.*, *J. Instn Chem. India*, 1953, **25**, 31;

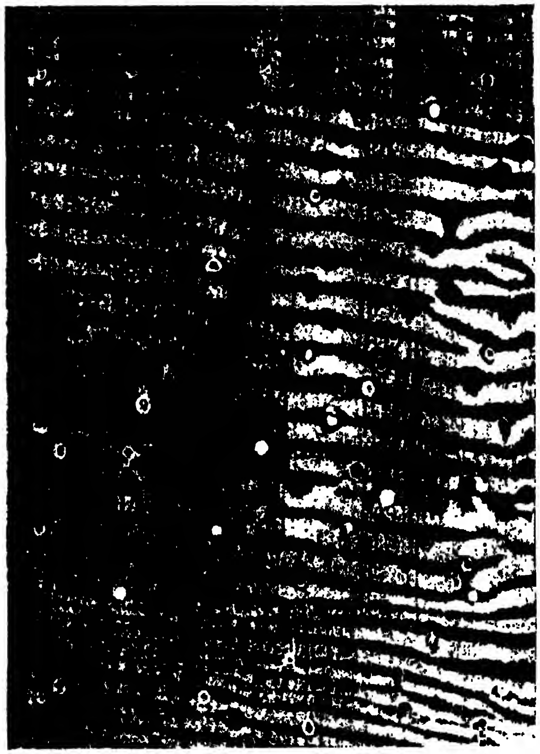
Rao & Rao, *Proc. Indian Acad. Sci.*, 1941, **14A,** 123; *J. Indian chem. Soc.*, 1940, **17,** 526].

A protein preparation (yield 23%, dry basis) suitable as a substitute for casein in the adhesive industries has been extracted from the seed cake with sodium carbonate. A good organic manure can be obtained as a by-product. Water paints obtained with the protein as binder are of good quality. The protein is also a good spreader adhesive for insecticidal sprays. Its use in the plastics industry has been suggested (Srinivasan & Subrahmanyan, *J. Indian Inst. Sci.*, 1934, **17A,** 49).

Wood—The wood is white and somewhat lustrous, aging to cream colour and often becoming dull, irregular or interlocked-grained, medium coarse-textured, moderately strong, tough, fibrous, hard and light to heavy (sp. gr., 0.747; wt., 593–865 kg./cu.m.). It is not durable and is very easily attacked by insects unless well seasoned. Water-seasoning is reported to reduce insect attack; graveyard tests show an average life of about two years. The wood is liable to split and warp badly in seasoning, but water-seasoning improves it. It is not difficult to saw, work, turn and finish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 110; strength as beam, 80; stiffness as beam, 85; suitability as post, 75; shock-resisting ability, 125; retention of shape, 60; shear, 110; and hardness, 100. A few fungi have been recorded to attack the wood (Pearson & Brown, I, 400–01; Gamble, 262; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 57, Sheet No. 16; Limaye & Sen, ibid., 1953, **1,** 96; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1,** 284).

The wood is used for yokes of bullock carts, ploughs, solid cart-wheels, rafters of thatched cottages, oil mills, furniture, small turnery articles such as planes, chisels, and screw drivers. Its use as pattern wood and as veneer for plywork has been suggested. The wood has been tried as a source of paper pulp in admixture with other hardwoods. The wood is commonly used as fuel: calorific value—4,839 cal., 8,710 B.t.u. The wood ash is reported to be used in dyeing. The twigs are used for cleaning teeth (Pearson & Brown, I, 402; Trotter, 1944, 194, 198; *Chem. Abstr.*, 1963, **58,** 7026; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

Destructive distillation of the wood gave the following products (dry basis): charcoal, 31.0; pyroligneous acid, 36.6; acid, 4.3; ester, 3.4; acetone, 1.9; methanol, 1.1; tar, 9.0; pitch and losses, 4.4%; and gas (at N.T.P.), 0.12 cu.m./kg. (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217).



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 80—PONGAMIA PINNATA—TRANSVERSE SECTION OF WOOD (×10)

Leaves—The leaves are lopped for fodder and are said to act as a galactagogue. They are rich in nitrogen, and contain 7.19 mg./100 g. of carotene. They are popular as green manure for rice and sugarcane fields, areca gardens and coffee plantations. Manurial value of the leaves and twigs are respectively: nitrogen, 1.16, 0.71; phosphorus (P_2O_5), 0.14, 0.11; potash (K_2O), 0.49, 0.62; and lime (CaO), 1.54, 1.58%. Green manuring with the leaves is reported to reduce the incidence of root-knot of tomato, caused by *Meloidogyne javanica*. Extracts of the leaves were active against *Micrococcus pyogenes* var. *aureus* [Use of Leguminous Plants, 236; Iyengar, *Mysore agric. J.*, 1956, **31,** 5; Acharya & Malpoorwala, *J. Univ. Bombay, N.S.*, 1952–53, **21A**(32), pt 3, 47; Nair *et al.*, *Madras agric. J.*, 1958, **45,** 114; Varadarajan & Sanyasi Raju, ibid., 1956, **43,** 59; Singh, loc. cit.; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B,** 261].

The juice of the leaves is prescribed in flatulence, dyspepsia, diarrhoea and cough; it is also considered

a remedy for leprosy and gonorrhoea. A hot infusion of the leaves is used as a medicated bath for relieving rheumatic pains, and for cleaning foul ulcers and sores (Kirt. & Basu, I, 830; Nadkarni, I, 1003).

Roots—The juice of the roots is used for cleansing foul ulcers and closing fistulous sores and for cleaning teeth and strengthening gums. The juice is also used in the treatment of gonorrhoea. A paste of the roots is used for local application in scrofulous enlargements. The roots are said to be used as fish-poison by the aborigines of Australia, the leaves being less potent in this respect (Burkill, II, 1798; Kirt. & Basu, I, 831; Nadkarni, I, 1004).

The root bark contains two closely related derivatives, kanugin ($C_{19}H_{18}O_7$, m.p. 203–05°) and demethoxy-kanugin (m.p. 146–47°). The stem bark also contains these compounds, but in minor amounts. Kanugin is feebly toxic to fish. The root bark from Australia has been reported to contain karanjin (0.08%) and pongapin (0.08%), and smaller amounts of two linear furanoflavones, pinnatin (m.p. 177–79°) and gamatin (m.p. 233–34°), which are isomeric with karanjin and pongapin respectively; the stem bark contains only waxes (Rangaswami *et al.*, *Proc. Indian Acad. Sci.*, 1942, **16A,** 319; Rajagopalan *et al.*, ibid., 1946, **23A,** 60; Rangaswami, *Curr. Sci.*, 1946, **15,** 127; Mittal & Seshadri, *J. chem. Soc.*, 1956, 2176; Row, *Aust. J. sci. Res.*, 1952, **5A,** 754; Pavanaram & Row, *Nature, Lond.*, 1955, **176,** 1177; *Aust. J. Chem.*, 1956, **9,** 132; Khanna & Seshadri, *Curr. Sci.*, 1964, **33,** 644).

Stem bark—The stem bark is fibrous and is used for cordage. The fresh bark has a feebly sweetish and mucilaginous taste at first, but soon becomes bitter combined with a sort of pungency. It is said to be given internally in bleeding piles. A decoction of the bark is used for beri-beri. In Bihar, the crushed bark is said to be given to buffalo calves to reduce their milk consumption. Alcoholic and aqueous extracts of the fresh bark are reported to exhibit marked antibacterial activity against *Micrococcus pyogenes* var. *aureus*. The bark shows positive tests for the presence of alkaloids and a triterpenoid saponin (Burkill, II, 1788–89; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 4, 1960, 15; Bressers, 47; Kurup, *J. sci. industr. Res.*, 1956, **15C,** 153; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 241, 1949, 31; Simes *et al.*, ibid., No. 281, 1959, 10).

Flowers—The dried flowers are used in decoction to quench thirst in diabetes. They also furnish good manure for pot plants and are said to be used in a well decomposed state for forcing chrysanthemum and other plants which require heavy feeding. They are a source of pollen for the honey-bee (Nadkarni, I, 1004; Gopalaswamiengar, 251; Latif *et al.*, *Pakist. J. sci. Res.*, 1958, **10,** 67).

The flowers contain an aliphatic waxy matter, free kaempferol, pongamin ($C_{15}H_{12}O_5$, m.p. 212°), γ-sitosterol glucoside, quercetin, neoglabrin (a complex amino acid resembling glabrin), and glabrosaponin ($C_{50}H_{84}O_{23}$) (Rama Murti & Seshadri, *Proc. Indian Acad. Sci.*, 1944, **20A,** 279; Pankajamani & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 93).

Ponies — *see* **Livestock,** Supplement to Wlth India—Raw Materials, VI

Poon — *see* **Calophyllum**

Popinac, White — *see* **Leucaena**

Poplar — *see* **Populus**

Poplar, Yellow — *see* **Liriodendron**

Poppy — *see* **Papaver**

Poppy, Californian — *see* **Eschscholzia**

Poppy, Mexican, Prickly — *see* **Argemone**

Poppy, Mexican Tulip — *see* **Hunnemannia**

POPULUS Linn. (*Salicaceae*)

A genus of deciduous, dioecious trees, commonly known as Poplars, Aspens and Cottonwoods, distributed chiefly in the North temperate zone, some species occurring in the sub-tropical regions. About 10 species occur wild in India.

Taxonomically, *Populus* is a bewildering genus. Several opinions exist regarding the limits and names of the species, as cross-fertilization occurs freely and several natural hybrids of ancient origin are known and new hybrids are being produced. There are three main groups: (*i*) White Poplars, having smooth white or grey bark; (*ii*) Black Poplars, possessing bark that soon becomes dark and fissured; and (*iii*) Balsam Poplars, which exude aromatic resins (Bailey, 1947, III, 2753; Streets, 618).

P. alba Linn. WHITE POPLAR

D.E.P., VI(1), 325; Fl. Br. Ind., V, 638; Kirt. & Basu, Pl. 919B.

N. W. HIMALAYAS—*Safeda, jangli-frast, chitta bagnu*; KASHMIR—*Fras.*

A medium-sized to large tree, native of Central Europe to Central Asia, found in the North-West Himalayas, at altitudes of 1,200–3,000 m.; also com-

monly grown in avenues. In its native region, the trees attain a height up to 30 m. or more, but in the Himalayas the trees are much smaller. Bark greyish or whitish, rough and furrowed on old trees; leaves variable in size and shape, 5–10 cm. long, sinuate or lobed, white tomentose beneath; flowers small, in hairy catkins; capsules c. 6 mm. long; seeds minute, hairy.

The tree thrives best on deep moist soil; it is sometimes found on hot and dry slopes with shallow soil and should be useful for afforestation of such slopes. Natural seedlings spring up on newly exposed ground or on recent alluvial deposits in the beds of streams. Artificial propagation may be done through stem and root cuttings or by transplanting suckers. Growth of the tree is fast, the annual girth increment being 2.6–4.0 cm. The leaves are affected by a rust, *Melampsora rostrupii* G. Wagner and a powdery mildew, *Uncinula salicis* Wint. Defoliators and borers have also been recorded on the tree [Troup, III, 963; Gamble, 692; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 284; Chona *et al.*, *Indian Phytopath.*, 1960, **13**, 72; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 53].

The wood (wt., 449–705 kg./cu.m.) is white, even-grained and soft. It is neither strong nor durable, but is easy to work and suitable for carving. The heartwood has a pungent odour due to the presence of a yellow gum and repels insects. The odour is not very strong in the seasoned wood, which, for this reason, is prized for furniture in some regions. It is suitable for cabinet-work, piano and violin parts, and small turnery articles. In Europe, it is used for interior construction of rail-road cars, sabots, and match-veneers. Light pieces of wood may be used for spars and ribs of aeroplanes. In Afghanistan, the wood is used for making boxes for packing grapes and in Italy, for manufacturing newsprint. Analysis of the sapwood and heartwood gave the following values, respectively (dry basis): moisture, 8.3, 9.3; ash, 1.0, 2.3; lignin, 29.1, 29.1; and cellulose, 50.0, 56.0%. The wood-wool is suitable for use in the manufacture of cooling pads, employed in room coolers (Gamble, 692; *Poplars*, FAO Forestry and Forest Product Studies, No. 12, 1958, 400, 480; Howard, 491; Uphof, 292; Bhargava, *Indian Pulp Pap.*, 1951–52, **6**, 20; Saikia *et al.*, *Res. & Ind.*, 1963, **8**, 3).

The bark possesses tonic, diuretic and antipyretic properties, and is reported to have been used as a substitute for quinine in Italy. It is also used in strangury and skin diseases. The bark contains two glycosides, viz. salicin ($C_{13}H_{18}O_7$, m.p. 201°) and populin (benzoyl salicin, $C_{20}H_{22}O_8$, m.p. 180°), a yellow colouring matter (crisin), and tannin (5–9%). Salicin is a bitter tonic and antiperiodic, and is used like quinine in intermittent fever. It is also administered in rheumatism, coryza and neuralgia. Both salicin and populin cause elimination of uric acid. The leaves contain populin and the buds salicylaldehyde (Kirt. & Basu, III, 2370; Hocking, 179; Medical Dictionary, 1319; Wehmer, I, 204; McIlroy, 15; B.P.C., 1954, 658; *Chem. Abstr.*, 1937, **31**, 5875; Wiesner, Lieferung 1, 278).

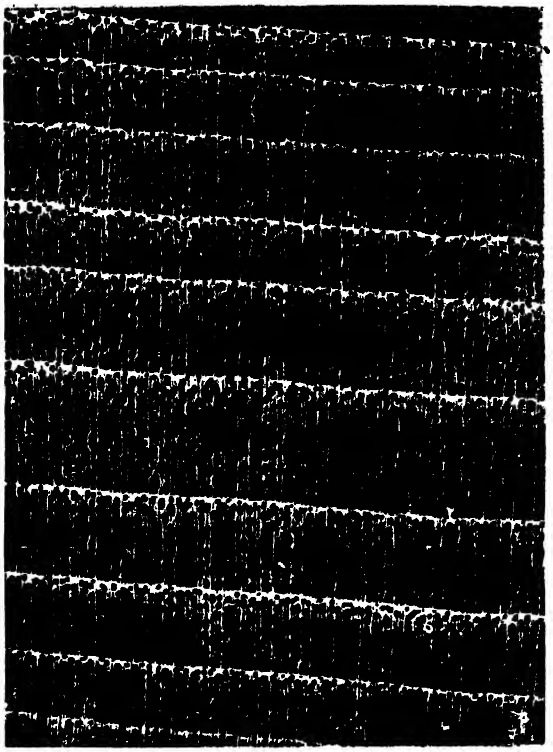
P. ciliata Wall. ex Royle HIMALAYAN POPLAR

D.E.P., VI(1), 326; Fl. Br. Ind., V, 638; Kirt. & Basu, Pl. 920.

N. W. HIMALAYAS—*Chalun, bagnu, tilaunja*; JAUNSAR—*Biaon, piplas, pahari-pipal*; KUMAUN—*Syan*; NEPAL & BENGAL—*Bangikat*.

A moderate-sized to large tree, attaining a height up to 36 m. and a girth up to 4 m., with a clean bole of about 21 m., found throughout the Himalayas at altitudes of 1,200–3,500 m., and also in the Aka hills of Assam. Bark dark grey, with longitudinal fissures; leaves 7.5–18.0 cm. long, broadly-ovate or ovate-lanceolate with serrulate-crenate and ciliate margin;

FIG. 81—POPULUS CILIATA—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 82—POPULUS CILIATA—TRANSVERSE SECTION OF WOOD (×10)

flowers small, in catkins; capsules ovoid, 7.5–10.0 mm. long; seeds minute, hairy.

The tree is reported to be cultivated in Shillong and is commonly grown as a roadside tree, especially in Kashmir. In the western Himalayas, the tree is common in mixed broad-leaved oak and coniferous forests. It thrives best in ravines on well-drained and porous soils. Sometimes, it occurs in pure patches on islands in the beds of streams. It withstands drought well and can grow on dry hill-sides; the tree may, therefore, be planted for the afforestation of unstable slopes. It is a light demander. Natural regeneration takes place freely through seeds during the early rains, the seedlings springing up all over the exposed ground. Natural regeneration through suckers is also very common. Artificial propagation may be done through stem cuttings or root suckers; one-year old rooted cuttings give the best results. Owing to the minute size of the seeds, raising of nursery plants requires considerable care. The tree pollards vigorously, but its coppicing power is generally poor. It has a fairly fast rate of growth with an annual girth increment of 1.8–2.5 cm. The tree is affected by several fungal diseases, including stem rot, *Boerlagella effusa* Syd. & Butler; leaf rust, *Melampsora ciliata* Barclay; and canker, *Nectria cinnabarina* Fr. Many borers and defoliators cause considerable damage, while some other insects produce galls on leaves and branches [Troup, III, 958–62; Seth & Desarker, *Indian For.*, 1960, **86**, 21; Gamble, 690; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 284; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 53; Mani, *Bull. bot. Surv. India*, 1965, **1**, 115].

The sapwood is nearly white, broad; heartwood yellowish white when first exposed, turning yellowish grey or brownish grey with age, somewhat lustrous, straight-grained, medium fine- and quite even-textured, moderately soft and light (sp. gr., *c.* 0.456; av. wt., 449 kg./cu.m.). It seasons well and quickly. The timber takes 5–7 days for kiln drying. Initial steaming of the charge for about two hours at 55°/100 per cent R.H. should be carried out to sterilize the wood. It is moderately durable under cover and in contact with water, but is liable to insect attack. It saws and works easily. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 65; strength as a beam, 50; stiffness as a beam, 75; suitability as a post, 55; shock-resisting ability, 70; retention of shape, 55; shear, 55; and hardness, 30. The wood is used for fruit-crates, water-troughs, cricket bats, and turnery. It is also suitable for artificial limbs, veneers, match-boxes, and splints. In Ladakh, it is used as fuel [Pearson & Brown, II, 1009–11; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 58, Sheet No. 17].

The wood is stated to be suitable for making paper pulp. Analysis of the wood gave the following values (dry basis): ash, 1.24; cellulose, 62.76; lignin, 25.31; and pentosans, 17.80%. Digestion of the wood by the sulphate process (total chemicals, 22.24%; digestion temp., 153.70°; digestion period, 6 hr.) gave bleached pulp in a yield of 50–52 per cent. The pulp had satisfactory strength properties for use in the manufacture of writing and printing papers. The pulp is short-fibred (av. length 1.14 mm., diam. 0.024 mm.), and requires admixture with long-fibred pulp, such as bamboo pulp (Guha & Mathur, *Indian Pulp Pap.*, 1959–60, **14**, 173; Guha *et al.*, ibid., 1966–67, **21**, 279).

The bark is used as a tonic, stimulant and blood purifier. The leaves are used as fodder for goats (Singh, *Indian For.*, 1950, **76**, 526; Kirt. & Basu, III, 2368).

P. euphratica Olivier Indian Poplar

D.E.P., VI(1), 326; Fl. Br. Ind., V, 638; Kirt. & Basu, Pl. 92B

Punjab & N. W. Himalayas—*Bahan, bhan*; Ladakh—*Hotung, hodung*.

A medium-sized tree, *c.* 15 m. in height and 2.5 m. in girth, found in the Punjab plains on the banks of the Sutlej and along its feeders in the western Himalayas, ascending to an altitude of *c.* 4,000 m. in Ladakh and western Tibet. Bark thick, rough; leaves very variable, linear-oblong to ovate-rhomboid, entire or lobulate, 7.5–15.0 cm. long; flowers small, in catkins; capsules ovoid-lanceolate, 7–12 mm. long; seeds minute, hairy.

The tree is typically gregarious, occurring pure or associated with other species. It reaches in elevation to the upper limits of tree growth, and is found even in the hottest parts in the plains, where it thrives under the mitigating influence of river inundations. It is a light demander and is frost hardy. Natural reproduction is through root suckers or seeds; the seedlings spring up on fresh alluvial soil after the floods recede. Artificial propagation through seeds or cuttings has not been very successful. The tree coppices well and stands pollarding for a long time. It is well adapted for treatment under coppice or coppice-with-standards, reproduction being obtained from root suckers and coppice shoots. The rate of growth of the tree is fast, the annual girth increment being 4.0–5.3 cm. The tree is attacked by a number of defoliators, borers and gall-forming pests [Troup, III, 963–65; Gamble, 691; Seth & Desarker, *Indian For.*, 1960, **86**, 21; Streets, 627; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 54].

The sapwood is white and broad; heartwood is reddish, often almost black at the centre, straight- to irregularly interlocked-grained, medium fine- but somewhat uneven-textured, moderately hard and light (wt., 481 kg./cu.m.). It seasons well without difficulty. The timber takes 5–7 days for kiln drying. Initial steaming of the charge for about two hours at 55°/100 per cent R.H. should be carried out to sterilize the wood. It is fairly durable under cover and in contact with water, but is liable to insect attack, especially in the green state. The wood is easy to saw and works to a good finish. It is a good turnery wood and can be peeled off on a rotary cutter. The wood is used for planking, well-curbs, lacquer-work, turnery, match-boxes, and splints. It is suitable for plywood, cricket bats, shoe heels, and bobbins. It is used as fuel; calorific value: sapwood—5,019 cal., 9,035 B.t.u.; heartwood—5,008 cal., 9,016 B.t.u. (Pearson & Brown, II, 1007–09; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956; Krishna & Ramaswami, ibid., No. 79, 1932, 21; Trotter, 1944, 198–99, 225).

The leaves afford a good fodder for sheep, goats and camels. The twigs are chewed and used for cleaning teeth in Punjab. The bark is reported to be a vermifuge (Kirt. & Basu, III, 2369).

P. laurifolia Ledeb. syn. *P. balsamifera* Hook. f. non Linn.

D.E.P., VI(1), 325; Fl. Br. Ind., V, 638.

N. W. Himalayas—*Phalsh, pakh*.

A large balsamiferous tree, up to 21 m. in height, remarkable for its handsome ovate leaves, found both wild and cultivated in the inner dry ranges of the North-West Himalayas at altitudes of 2,400–4,000 m.

This species has long been confused with *P. balsamifera* Linn., a tree of North America and Siberia; the latter is a source of the Poplar Buds, used in medicine and cottonwood timber. The identity and nomenclature of the Linnean species is much disputed (Streets, 630; Record & Hess, 485; U.S.D., 1955, 1088).

The tree exudes a balsamic juice when freshly cut between the bark and the wood. The wood (wt., 513 kg./cu.m.) is used much as fuel and the branches are lopped for cattle fodder.

P. nigra Linn. var. **italica** Koehne syn. *P. italica* Moench.; *P. nigra* var. *pyramidalis* Spach

Lombardy Poplar

D.E.P., VI(1), 327; Fl. Br. Ind., V, 638; Kirt. & Basu, Pl. 919A.

N. W. Himalayas—*Frast, farsh, sufeda*.

A large tree, up to 30 m. in height and 3 m. in girth, with a narrow pyramidal crown and viscid buds, cultivated in the North-West Himalayas at altitudes of 900–3,700 m.; also planted in avenues, especially in Kashmir. Bark grey, rough, deeply furrowed in old trees; leaves ovate-rhomboid, 5–10 cm. long; flowers in catkins, up to 10 cm. long. For economic purposes, the variety *italica* is not much differentiated from *P. nigra* Linn. (Black Poplar), a large tree distributed in Europe, North Africa and western Asia.

Lombardy poplar grows on comparatively dry ground and is useful for afforesting unstable slopes. It rarely flowers in India and is raised from stem or root cuttings, and also from root suckers, which are produced mostly after the tree is cut down. It pollards

I.C.A.R., New Delhi

POPULUS NIGRA VAR. ITALICA—AN AVENUE

well, and has a fast rate of growth. The tree is attacked by desert locust and a gall-forming insect [Troup, III, 962; Mathur & Balwant Singh, *Indian For. Bull.*, *N.S.*, No. 171(7), 1959, 55].

The wood is brownish, even-grained, soft and light (wt., 417–560 kg./cu.m.). It is said to harden with age to such a degree that it can be nailed only with great difficulty. It is reported to be suitable for second quality match-splints. In Afghanistan, the wood is used like the wood of *P. alba*, for making small boxes for packing grapes. It is said to be used in some countries for poles, truck and barrow-trays, coaches, furniture, and cross-beams, and also as farm timber and fuel. Activated carbon of good quality is obtained from the sawdust (Gamble, 692; Trotter, 1944, 214; *Poplars*, FAO Forestry and Forest Product Studies, No. 12, 1958, 461; *For. Abstr.*, 1950–51, **12**, 506).

The shoots are lopped for fodder. An ointment prepared from the leaf buds is reported to be used for haemorrhoids. The balsam from the buds is used as a remedy for colds.

The leaf buds of *P. nigra* contain salicin, populin, an essential oil (0.5%), and 0.25 per cent of a yellow colouring matter, chrysin ($C_{15}H_{10}O_4$, m.p. 275°). The essential oil is yellow to light brown in colour and has an agreeable aroma, somewhat reminiscent of chamomile oil. It has the following physico-chemical properties: sp. gr., 0.8906–0.9035; n_D, 1.4962–1.4966; $[\alpha]_D$, 3.9–6.0°; acid val., 1.9–11.3; ester val., 7.5–13.4; and ester val. after acetylation, 18–53. The oil contains sesquiterpenes, viz. humulene (α-caryophyllene) and populene, some alcohols and paraffins. The oil has no commercial value. Chrysin is a feeble dye; bright yellow, pale yellow-orange, and chocolate-brown shades are produced on wool with this dye, using aluminium, chromium and iron respectively as mordants. A small amount of a second colouring matter, tectochrysin (chrysin monoethyl ether) is also found along with chrysin (Uphof, 293; Wehmer, I, 205; Perkin & Everest, 141; Finnemore, 202; Guenther, II, 752).

The bark extract is considered depurative and is used against colds. Tannin is present in the bark (5.0–9.7%) and in the leaves (18.7%). Salicin is also present in both the bark and the leaves (Kirt. & Basu, III, 2367; Wehmer, I, 205; Wiesner, Lieferung 1, 277; *Chem. Abstr.*, 1938, **32**, 3189).

Experiments on the introduction of exotic poplars into India have been conducted by the Forest Research Institute, Dehra Dun since 1958, when a number of clones from the U.K. were introduced and multiplied. So far over 160 species and hybrids and clones have been tried, of which only 68 continue to grow; the results, however, are inconclusive. In the moist localities of Almora and Chakrata hills in Uttar Pradesh, the clones of *P. yunnanensis* Dode and *P. robusta* Schneid. have shown some promise; and in the plains of northern Terai, *P. deltoides* Marsh. and some clones of *P. casale* have given good results.

The trials indicate that poplars require a sub-tropical or temperate climate and sufficient soil-moisture with a high water-table. They are strong light demanders and do much better under irrigation. It has been suggested that Terai region of Uttar Pradesh, Bihar and West Bengal, and sub-Himalayan tracts of Himachal Pradesh are suitable localities for cultivation of poplars (Paper No. I.G. 3, 11th All India Silvicultural Conference: Information from the Central Silviculturist, Forest Research Institute, Dehra Dun).

P. deltoides Marsh. (Caroline Poplar), a native of North America, yields timber which is almost white, light and soft, fairly straight-grained, easy to work and peel, taking glue, paint and polish well, and holds nails excellently. It is used for match and other veneers, plywood boxes and packing cases, pulp and wood-wool. In Kashmir, the wood has gained importance for the manufacture of boxes for packing fruits. *P. robusta* Schneid. is a Black Poplar hybrid, which is said to have originated in France. It is normally resistant to bacterial canker and is much used in Belgium and Sweden for the manufacture of matches. *P. yunnanensis* Dode (Yunnan Poplar), a native of South-West China, is a frost hardy tree and may be grown for its attractive foliage, and as a parent for hybrids (Streets, 624, 633, 638; Sagreiya, *Indian For.*, 1963, **89**, 253).

PORANA Burm. f. (*Convolvulaceae*)

A small genus of woody or herbaceous twiners distributed mostly in tropical and sub-tropical Asia, and a few in Africa and adjacent islands, Australia and America. Seven species occur in India.

P. paniculata Roxb. Bridal Creeper

Fl. Br. Ind., IV, 222; Fl. Malesiana, Ser. I, **4**(4), 404, Fig. 10.

Uttar Pradesh—*Belkamu, safed bel;* Kumaun—*Baruni;* Mundari—*Hundi ba;* Assam—*Rikamir.*

A large woody twiner found almost throughout northern India, particularly in the open scrub and

miscellaneous forests of Uttar Pradesh and Bihar, and ascending up to 1,350 m. in the hills. Leaves ovate, cordate; flowers white, funnel-shaped, in dense panicles; capsules ovoid-globular.

The plant is often cultivated in gardens as an ornamental for its dense mass of white flowers. It is well suited for covering walls and trellises, and can be propagated by cuttings or layering. The flowers which have a faint but most agreeable lavender-like fragrance are used in bridal bouquets and in flower vases. In Saharanpur district, the stems are used for making coarse baskets and are said to be preferred for this purpose to other plants. The herbaceous parts are used for medicinal purposes in Bihar. The leaves contain chlorogenic acid (Gopalaswamiengar, 362; Firminger, 433; Rama Rao, 282; Gupta, 342; Bressers, 100; Wehmer, II, 1014).

P. racemosa Roxb. syn. *P. malabarica* C. B. Clarke; *P. truncata* Kurz SNOW CREEPER

D.E.P., VI(1), 327; Fl. Br. Ind., IV, 222; Talbot, II, Fig. 432.

MAR.—*Bhowri, gariya.*

A slender, extensive climber found nearly throughout India, from Garhwal eastwards in sub-tropical Himalayas up to Bhutan, in Khasi hills and in the western ghats and hills of Deccan and South India. Leaves ovate, deeply cordate, rarely pubescent to tomentose; flowers white, in dense paniculate inflorescences; capsules ovoid, glabrous.

The plants occurring in Deccan and South India were considered to be a distinct species *P. malabarica* C. B. Clarke, but recently they have been shown to be only variants of this species (Santapau & Patel, Prof. Agharkar Commemoration Volume, 1961, 13).

This species, like the previous one, is often cultivated for its dense mass of dazzling flowers borne in profusion (Percy-Lancaster, 319).

The peduncles of the plant are reported to be eaten in Deccan in times of scarcity.

P. volubilis Burm. f. WHITE CORALLINA

Fl. Br. Ind., IV, 222; Fl. Malesiana, Ser. I, 4(4), 402, Fig. 8–9.

A large woody twiner, indigenous from Burma and Indo-China to Malaysia, often cultivated in gardens in India as an ornamental. Leaves ovate, mostly broadly rounded; flowers white, fragrant, in dense panicles; capsules broad-ovoid to globose; seed ovoid, purple-brown or black.

The stem is reported to contain an alkaloid. A decoction of the plant is given after child-birth as a purifying medicine. The leaves are eaten to remove nasty taste from the mouth and the juice used as an ingredient of a tonic (Willaman & Schubert, *Tech. Bull. U.S. Dep. Agric.*, No. 1234, 1961, 77; Burkill, II, 1800).

FIG. 83—PORANA PANICULATA—FLOWERING BRANCH

Porcelain — *see* **Clays**

Porcupines — *see* **Rodents**

Pork — *see* **Livestock,** supplement to Wlth India—Raw Materials, VI

PORPOISES AND DOLPHINS (Class *Mammalia*, order *Cetacea*, suborder *Odontoceti*)

D.E.P., VI(4), 303; Fl. Br. Ind., Mammalia, 73, 578.

The order *Cetacea* includes whales, porpoises and dolphins which are found in all oceans; some species also inhabit the larger rivers of South America and Asia. The cetaceans live on various types of animals, such as fish, crustaceans, pteropods, cuttle-fish, etc., some grampuses or killers, as they are called, hunting not only seals and dolphins, but also large whales. The existing members of the order fall into two

suborders, viz. *Odontoceti* (Toothed-whales) and *Mysticeti* (Whalebone or Baleen-whales). *Odontoceti* comprises a large variety of forms, such as porpoises, dolphins, killer- and sperm-whales. The whalebone whales and the larger of the toothed-whales, such as Indian Pilot-whale (*Globicephala macrorhynca* Gray), Killer-whale or Grampus [*Orcinus orca* (Linn.)] and False Killer-whale [*Pseudorca crassidens* (Owen)] will be described in a separate article on Whales while the rest of the economically important toothed-whales are dealt with here.

In the toothed-whales, the teeth are usually present in one or both jaws and whalebone is never developed. The nostrils have a common opening or blow-hole which is situated asymmetrically, and the nasal bones are very small. Dolphins mainly differ from porpoises in having a distinct beak which is the prolongation of the snout.

Porpoises and dolphins are fish-like aquatic mammals, preferring bays, estuaries and coastal areas to open seas, a few species occupying inland waters also. These aquatic cetaceans were once regarded as having some affinity with *Carnivora*, but later investigations have shown that they are more allied to ungulates.

Porpoises and dolphins possess, besides an external fish-like form, certain adaptations for an aquatic mode of life. They include paddle-like fore limbs or flippers with fused digits, flattened tail modified into horizontal flukes and, in many species, the absence of hind limbs and the presence of a dorsal fin formed of integument of the body. The animal swims by means of up and down strokes of the powerful tail; the flippers, aided by the fin on the back, act as balancers. Skin is smooth and hairless except for a few bristles round the mouth in the young forms. The heat of the body is maintained by a thick layer of fat or blubber which lies beneath the skin. It also helps to keep up the buoyancy of the animal in water. Eyes are small and external ears are absent: ear orifice is minute. Gill or gill openings, characteristic of fishes, are completely absent; the respiration is by lungs. If the animals are kept out of water for a long time on land they die of suffocation on account of the pressure of the body weight on their lungs. Food is swallowed entire without mastication. Two teats are present in the female, one on either side of the genital orifice. Only one, or rarely two, young ones are given birth to at a time, each measuring not less than 0.9 m. in size. The period of gestation is usually less than a year.

Porpoises and dolphins have in their head, jaw and blubber, depot fats which are unique in containing large amounts of *iso*valeric acid. The oils from head and jaw of the Common Porpoise (*Phocaena phocoena* Linn.) contain more of *iso*valeric acid than the body oil while the oils from liver and other organs do not contain this acid.

Porpoises and dolphins are economically very important. The soft depot fat, obtained from the head and jaw of the animals, is used as a lubricant for delicate machines and instruments. Most of the forms yield meat of good quality which has been considered a delicacy (Pycraft, 809–16; Regan, 820–23; Sterndale, 125–29; Jerdon, 1867, 156 60; Thomson, 934; Encyclopaedia Britannica, V, 169–73; VII, 511; XVIII, 243).

Porpoises and dolphins of the following genera are represented in Indian waters: *Neomeris* (Gray) of the family *Phocaenidae*; *Orcaella* (Gray), *Lagenorhynchus* (Gray), *Tursiops* (Gervais), *Steno* (Gray), *Delphinus* Linn. and *Sotalia* (Gray) of the family *Delphinidae*; and *Platanista* (Wagler) of the family *Platanistidae* (Ellerman & Morrison-Scott, 719–20, 729-31, 733–36, 738, 741).

Little Indian Porpoise, *Neomeris phocaenoides* (Cuvier) (Mar.—*Bhulga*; Tam. *Molagan*), is the black finless porpoise recorded from the tidal rivers near Calcutta and inshore waters of the Indian Ocean on the Madras and Malabar coasts. It haunts shallow waters in estuaries and backwaters and is not very active in habits. This small-sized porpoise is without a dorsal fin, a feature which is characteristic of other Indian species. About 18 teeth are present on each ramus of the jaw; snout is rounded and colour of the propoise is black throughout. The animal measures about 1.3 m. in length and 0.8 m. in girth and weighs nearly 27.3 kg. It is occasionally caught in the fishing nets on the west coast, especially off Kerala, and is locally consumed. The porpoise hide of commerce is obtained from this species and it constitutes an important fishery in a few foreign countries. The oil obtained from the soft fat of the head and jaw of this porpoise is an excellent instrument oil, noted for its spreading power, and used as a lubricant for watches and such other delicate mechanisms. Its value lies chiefly in the fact that it is free from a tendency either to thicken by oxidation or to corrode any metal. It is capable of withstanding exposure to very low temperatures without freezing or thickening to any great extent. The oil of this porpoise may have many of the physico-chemical

properties of the oil of common porpoise of North Pacific and North Atlantic Oceans (Sunderland, *Progr. Rep. Pacif. Coast Sta.*, 1932, **14**, 14).

Irrawaddy Dolphin or Larger Indian Porpoise, *Orcaella brevirostris* (Owen), occurs in the Bay of Bengal and is commonly found in Vishakhapatnam harbour, Andhra Pradesh. It is gregarious in its habit. It ascends the rivers as far as the tides extend. Colour is slaty blue or nearly black above, a little paler below. It feeds on fish.

Indian Broad-beaked Dolphin, *Lagenorhynchus electra* Gray, is a short, dark coloured porpoise with a broad beak and snout. It is recorded from the sea on the east coast at Vishakhapatnam. Beakless Dolphin, *L. obscurus* (Gray), was reported to occur in the Indian Ocean near the Palk Straits.

Bottle-nosed Dolphin, *Tursiops truncatus* (Montagu), is reported to inhabit the Bay of Bengal. A sample of oil obtained from the jaw of the dolphin had the following characteristics: $d^{15.5°}$, 0.9241; $n^{20.5°}$, 1.4519; sap. val., 293; iod. val., 28.3; R.M. val., 139; acid val., 2.88; and viscosity, 20.46 cp.; fatty acid composition: *iso*valeric, 86.7; palmitic, 8.4; and oleic, 4.9%. The oil contained about 19 per cent of higher fatty alcohols in addition to glycerides (Thorpe, IX, 36–37; Kirk & Othmer, XV, 9–10; Hilditch, 1956, 67–69, 400; *Chem. Abstr.*, 1930, **24**, 3666).

Red Sea Bottle-nosed Dolphin, *Tursiops aduncus* (Ehrenberg) syn. *Delphinus perniger* Blyth, *D.* (*Steno*) *gadamu* Owen (Tel.—*Gadamu*), occurs on the east coast near Vishakhapatnam. It is a stout porpoise with a moderately tapering beak; colour is dark slate above, shading into pale grey below. Records of occasional catches show that a few more species, viz. *T. fergusoni* Lydekkar and *T. dawsoni* Lydekkar also inhabit the waters off Trivandrum and Vizhingam, Kerala State.

Rough-toothed Dolphin, *Steno bredanensis* (Lesson) syn. *Delphinus frontatus* Cuvier, is commonly captured from the Bay of Bengal near Nicobar Islands. Head is prolonged into a distinct narrow snout; colour is very variable.

Spot-bellied Dolphin, *Delphinus* (*Steno?*) *maculiventer* Owen (Tel.—*Suvva*), is reported to occur in the waters of the east coast near Vishakhapatnam. Colour is black above and greyish below with irregular dark spots or blotches.

Common Dolphin, *Delphinus delphis* Linn. (Tam.—*Pomigra*), is generally found in the warm and temperate seas. In India, it is recorded only from the coast of Madras; it is mostly gregarious, moving actively in herds by rapidly swinging its tails. It is an elegant, slim-bodied dolphin with a long, distinct beak and flippers. Colour is variable from black to black grey. It feeds chiefly on fish.

Common dolphin is made up of: edible flesh, 38.0; skin and blubber, 16.0; head, 10.0; bones, 16.5; tail and fins, 2.5; liver, 2.5; intestines, 7.0; and other viscera, 4.0%. The flesh contains: moisture, 73.0; protein, 23.5; fat, 1.5; and ash, 1.8%. It is nutritious and is used as a food in Ceylon and other places particularly when fish supply is in shortage. It can be used in the preparation of a variety of dishes. The cooked meat is dark and resembles beef in texture and flavour. The meat can also be made into sun-dried salted strips or cured into a standard sweet-pickle mixture which keeps well for months under cold storage.

The unused portions of the dolphin, such as parts of the head, bones, viscera and flesh trimmings can be processed into a meal, which like fish meal, may be used in animal feeds or for soil fertilization. The skin of the dolphin has been tanned to produce two kinds of leather of an excellent quality, one of a light biscuit colour and the other black (Lantz & Gunasekera, *Bull. Dep. Fish., Ceylon*, No. 3).

Indian Long-nosed Dolphin, *Delphinus dussumieri* Blanford, is reported to occur in the waters along the coast off Malabar.

Plumbeous Dolphin, *Sotalia plumbea* (Cuvier) syn. *Delphinus plumbeus* Cuvier, inhabits the Indian Ocean and is recorded from Madras and Malabar coasts. Colour is uniform, plumbeous grey except at the extremity and underside of the lower jaw where it is white.

Speckled Dolphin, *Sotalia lentiginosa* (Owen) syn. *Delphinus* (*Steno?*) *lentiginosus* Owen (Tel.—*Bolla*

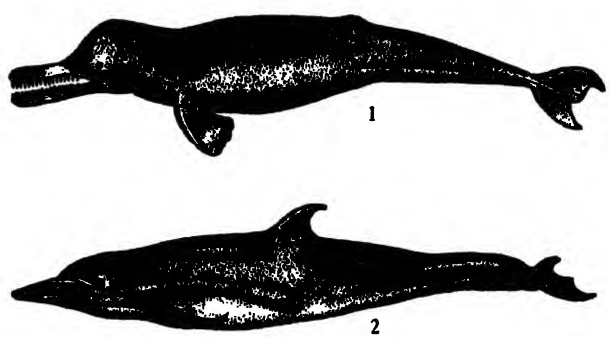


FIG. 84—DOLPHINS: 1, The Gangetic Dolphin (Platanista gangetica); 2, The Common Dolphin (Delphinus delphis) (×0.03)

gadini), is reported to occur in the seas at Vishakhapatnam, Andhra Pradesh and Alibagh, near Bombay. This animal is uniformly bluish or slate coloured, freckled with irregular small spots of brown or plumbeous pigments (Lydekkar, *J. Bombay nat. Hist. Soc.*, 1903–04, **15**, 38, 408; 1904–05, **16**, 730).

Gangetic Dolphin, *Platanista gangetica* (Lebeck) (SANS.—*Sisumar*; HINDI *Sus, susu, sous, susa*; BENG.—*Susuk, sishuk*; ASSAM *Hiho, seho*; CACHAR —*Huh*), is a fluviatile or estuarine species, commonly found in the Ganga, Brahmaputra and Indus rivers and their large tributaries. It is most abundant in the middle and lower portions of these rivers. Though not gregarious, this dolphin moves in small groups and is probably migratory in nature since it is not found to occur in the Hooghly river near Calcutta during March–June whereas it frequents the river from October to March.

The gangetic dolphin is quite blind probably because of the muddy water surroundings where it dwells. It preys on fishes and prawns discovering them mainly in the mud at the bottom by probing with its long, slender and beak-like jaws, which are provided with about 28/29 teeth on each side. Teeth undergo changes, being pointed in young and becoming very blunt and broad-rooted as the animal grows up. Colour of the animal is black throughout to match the turbid waters it frequents. It measures about 2.5 m. in length: female is considerably larger than the male, which is also thickly set with a shorter muzzle. The period of gestation is 8–9 months and usually only one young is born at a time between April and July. Young dolphins are sometimes caught clinging by the mouth to the base of the parent's flippers.

The flesh of this species is eaten, especially in Garhwal, where nets or harpoons are used to catch them: it is rarely taken by fishermen. The oil obtained from its fat is used as an embrocation in cases of rheumatism. The illumination power of the oil is reported to be very high.

Portia Tree — *see* **Thespesia**

PORTULACA Linn. (*Portulacaceae*)

A genus of succulent herbs distributed in the warmer parts of the world. Four species are found wild in India and two exotics have become naturalized.

P. oleracea Linn. COMMON PURSLANE

D.E.P., VI(1), 329; Fl. Br. Ind., I, 246.

SANS. *Brihalloni, lonika, lonamla*; HINDI—*Khursa, baralaniya, kulfa*; BENG.—*Baraloniya*; MAR. *Bhuigholi, kurfah, mhotighol*; GUJ.—*Moti loni, ghol*; TEL.—*Peddapayilikura, ganga-pavilikura*; TAM.—*Karikeerai, paruppukiray, pullikirai*; KAN. *Doodda-gooni soppu*; MAL.—*Karieecheera*; ORIYA—*Puruni-sag*.

ASSAM—*Noniya*; PUNJAB *Lonak, kundar*.

A succulent, prostrate or erect annual, with green or purple stems, up to c. 50 cm. long, found throughout India as a weed, ascending up to an altitude of 1,500 m. in the Himalayas; also cultivated as a vegetable. Leaves variable, oblong-ovate, spathulate, linear, with a cuneate, sessile base, 6–25 mm. long, fleshy: flowers bright yellow, in terminal, sometimes axillary clusters; capsules ovoid; seeds black, muriculate.

Two varieties are distinguished in this species: (*i*) the common wild variety, var. *oleracea* syn. *P. oleracea* var. *sylvestris* DC.; and (*ii*) the cultivated variety, var. *sativa* DC. (KITCHEN GARDEN PURSLANE). The latter is a more upright one and is considered better in quality and yield. There are several garden races grown in Europe, of which the Green, the Golden and the Large-leaved Golden are more important [Bailey, 1947, III, 2766; Cobley, 306; Chatterjee & Randhawa, *Indian J. Hort.*, 1952, **9**(4), 78].

Purslane is cultivated in the plains from March to June and in the hills from the middle of April to the middle of September. It can be grown in a variety of soils thriving best on a rich loam. Farmyard manure is applied at the rate of *c.* 40 cart loads per hectare during the preparation of the land. The seeds are mixed with sand and thinly broadcast at the rate of *c.* 2–3 kg. per hectare. The crop is irrigated once a week after primary irrigation, and it is ready for harvesting in about 60 days from sowing. Repeated sowings, once in a fortnight, are desirable for ensuring a constant supply (Purewal, 79; Gollan, 90).

Purslane has an acid taste and is used as a potherb; it is also consumed as salad and employed in soups. Fleshy stems are pickled; they are also dried and preserved for use in times of scarcity. The herb can be used with caution as a fodder for sheep, cattle and pigs. In the experimental trials, however, heavy ingestion of this plant proved toxic and even fatal to the animals due to oxalic acid poisoning [Singh, *Indian J. agric. Sci.*, 1945, **15**, 297; Medsger, 144; Shiu-ying Hu, *Acta phytother., Amst.*, 1955, **2**(4), 15; Mathams & Sutherland, *Qd J. agric. Sci.*, 1952, **9**, 317; Dalziel, 31].

Analysis of edible leaves and stems (51% of herb) gave: moisture, 90.5; protein, 2.4; ether extr., 0.6; crude fibre, 1.3; carbohydrates, 2.9; and mineral matter, 2.3%; calcium, 111; magnesium, 120; oxalic acid, 1,679; total phosphorus, 45; phytin phosphorus, 4; total iron, 14.8; ionisable iron, 1.0; sodium, 67.2; potassium, 716; copper, 0.19; sulphur, 63; chlorine, 73; thiamine, 0.10; riboflavin, 0.22; nicotinic acid, 0.7; and vitamin C, 29 mg./100 g.; carotene (as vitamin A), 3,820 I.U./100 g. Vitamin C is the highest in the green leaves of young plants and decreases after flowering. A sample from North India contained 16 mg./100 g. of total carotenoids, of which about one-third were active in terms of β-carotene (vitamin A potency, 7,500 I.U./100 g.). The oxalic acid content is by far in excess and cannot be compensated by the fairly high amount of calcium present. Purslane is also rich in sodium and potassium (Nutritive Value of Indian Foods, 56, 93, 125; *Chem. Abstr.*, 1947, **41,** 6935; Sadana & Ahmed, *J. sci. industr. Res.*, 1947, **6B,** 47).

The herb is considered to possess refrigerant, vulnerary, antiscorbutic, aperient and diuretic properties; the diuretic action is probably due to the presence of high percentage of potassium salts. It is useful in scurvy and in the diseases of liver, spleen, kidney and bladder. It is also prescribed in the treatment of cardio-vascular diseases, dysuria, haematuria, gonorrhoea, dysentery, sore nipples and ulcers of the mouth. The juice of the plant is sometimes used in earache and toothache. In homoeopathy, the herb is used to increase the flow of gastric juice and as a blood purifier. A paste of the leaves is applied to burns, scalds, swellings and erysipelas. The leaves and tops are employed in anti-haemorrhagic poultices (Kirt. & Basu, I, 242–43; Jacobs & Burlage, 172; *Chem. Abstr.*, 1951, **45,** 823; Quisumbing, 282–83; Hoppe, 729; Feng *et al.*, *Nature, Lond.*, 1961, **191,** 1108; Chandrasena, 14; Dalziel, 31).

The aqueous and ether extracts of the herb showed activity against Gram-negative bacteria. The oral administration of the homogenates of *P. oleracea* reduced the blood-sugar level of alloxan-diabetic rabbits to normal. A crude protein-free extract gave a strong pressor response when injected intravenously into anaesthetized dogs; it was found to contain biologically active *l*-noradrenaline dopamine [4-(2-aminoethyl) pyrocatechol], and dopa [3-(3,4-dihydroxyphenyl) alanine], besides an unidentified catechol. The concentration of *l*-noradrenaline in the fresh plant (2.5 mg./g. in one sample) is likely to be greater than that extractable from the suprarenal glands of the mammals. The herb probably contains the bioflavonoid liquiritin. Macerated herb exhibited carbonic anhydrase activity (Nickell, *Econ. Bot.*, 1959, **13,** 302; *Biol. Abstr.*, 1963, **42,** 495; Feng *et al.*, loc. cit.; *Chem. Abstr.*, 1956, **50,** 5099; 1962, **56,** 2714; Ganju & Puri, *Indian J. med. Res.*, 1959, **47,** 563).

The roasted seeds are said to be eaten. They are considered diuretic and antidysenteric. The seeds are also used in applications for burns and scalds. In general, their medicinal uses are similar to those mentioned for the herb. The seeds on extraction with petroleum ether give a light green oil (17.4%) with the following characteristics: sp. gr.$^{33°}$, 0.8162; $n_D^{30°}$, 1.4713; acid val., 15.8; sap. val., 189.9; acet. val., 21.3; iod. val. (Wijs), 135.3; R.M. val., 0.8; Polenske val., 1.6; Hehner val., 94.9; and unsapon. matter, 1.5%. The constituent fatty acids are: palmitic, 10.9; stearic, 3.7; behenic, 1.3; oleic, 28.7; linoleic, 38.9; and linolenic, 9.9%; unsaponifiable fraction yields β-sitosterol (Dalziel, 31; Quisumbing, 284; Nadkarni, I, 1006; Handa *et al.*, *J. sci. industr. Res.*, 1956, **15B,** 726).

Purslane being rich in minerals, can be used as green manure, but owing to its high sodium content prolonged use is likely to increase the salinity of the soil. Further, the plant may become a troublesome weed in some places, as it is very prolific in setting seeds, which retain their viability for over 30 years. The best method of control is to burn the plants when in seed. Application of 0.15 per cent solution of ammonium salt of 2,4-D at the rate of 565–1,135 litres per hectare is reported to control this weed selectively in several crops. The herb also appears to be a symptomless carrier of a pathogen, a *Rhizoctonia* sp. [Patil & Pandya, *Indian J. Agron.*, 1963, **8**(1), 378 Patil, *Poona agric. Coll. Mag.*, 1960–61, **51**(3 & 4), 32 Mudaliar & Rao, 91–93; *Chem. Abstr.*, 1947, **41,** 2196 *McGraw-Hill Yearb. Sci. & Technol.*, 1962, 411].

P. quadrifida Linn.

D.E.P., VI(1), 330; Fl. Br. Ind., I, 247; Kirt. & Basu, Pl. 96A.

SANS.—*Laghulonika, uppadyki*; HINDI—*Chounlayi, chotaluma, loniya, khate chawal*; BENG.—*Nuniya, chota luniya*; MAR.—*Kathechanval, ranghol*; GUJ.—*Luni, jhiniluni*; TEL.—*Payala kura, pavili, goddu-pavili kura*; TAM.—*Chinnaparpukkirai*; KAN.—*Gooni soppu, hali dajjili, halibachcheli*; MAL.—*Neelakeera*.

A small diffused, succulent annual found throughout the warmer parts of India. Leaves elliptic, ovate

or ovate-lanceolate, 3–6 mm. long; flowers yellow, solitary terminal; capsules conical; seeds minutely tubercled.

The herb is a troublesome weed; small bits of plants strike roots, and flowers left on such bits produce viable seed. The best method of control is to burn the weed (Rao & Ramanjaneyulu, *Madras agric. J.*, 1953, **44**, 50; Mudaliar & Rao, 94–95).

The herb is used as a vegetable in the same way as *P. oleracea*, but it is not very wholesome; excessive use may cause stupefaction. Its medicinal uses are more or less similar to those of *P. oleracea*. It is said to be useful in asthma, cough, urinary discharges, inflammations and ulcers. A poultice of the herb is applied in abdominal complaints, erysipelas and haemorrhoids (Rama Rao, 27; Kirt. & Basu, I, 244–45; Burkill, II, 1802).

P. grandiflora Hook. (Rose Moss), a native of South America, is a succulent, prostrate or ascending, pretty annual, with sun-blooming flowers of various colours, rose, red, white, yellow and variegated. It is very common in the Indian gardens and has run wild at some places. Double-flowered varieties are very attractive. The plant needs full sun. It is suitable for edging large plants in tubs and vases and rockeries and for growing on small boundary walls, where it hangs decoratively. It may be raised by cuttings or from seed. The flowers are frequented by bees. Extract of the herb is reported to completely inhibit the activity of water-melon mosaic virus on *Cucurbita pepo* var. *caserta* (Gopalaswamiengar, 456; Firminger, 612; Bruggeman, 51; Bhargava & Singh, *Curr. Sci.*, 1965, **34**, 361).

P. pilosa Linn., a native of tropical America, is a herb with fleshy linear leaves and pink or red flowers, introduced into the Indian gardens and also met with as an escape. It is a useful edging plant. The herb is said to be a febrifuge, antiseptic, diuretic and aperient. It is used in poultices for the treatment of boils in the groin (Mayuranathan, 33; Williams & Williams, 262; Dymock, Warden & Hooper, I, 159; Jacobs & Burlage, 172; Burkill & Haniff, *Gdns' Bull.*, 1929–30, **6**, 172).

P. tuberosa Roxb. (Beng.—*Laniya*; Mar.—*Jangli gajar*; Tel.—*Bodda kura*) is a spreading, perennial herb, with thick fusiform roots, linear-oblong, succulent leaves and yellow flowers, commonly met with in the Deccan Peninsula, especially near the sea coast. It is eaten as a pot-herb and is considered superior to *P. oleracea* in some places. The leaves are used as an external application in erysipelas and an infusion of the herb is prescribed in dysuria (Kirt. & Basu, II, 246).

PORTULACARIA Jacq. (*Portulacaceae*)

Chittenden, III, 1647.

A small genus of shrubs or small trees distributed in southern Africa. *P. afra* is reported to be grown in Indian gardens for ornament.

P. afra Jacq. (Speckboom, Elephant's Food) is a shrub or small tree, 4–5 m. high, with obovate-roundish, fleshy leaves and small, pink flowers. It is propagated by cuttings and is considered suitable as a hedge or border plant (Firminger, 613; Read, *Indian Fmg*, 1940, **1**, 117).

In South Africa, it is valued as a bee-plant and as stock feed. The hay prepared from its leaves gave (on dry basis): crude protein, 8.5; ether extr., 3.8; crude fibre, 20.9; N-free extr., 57.0; and total ash, 9.8% (Read, loc. cit.; Neal, 295; *Jt Publ. imp. agric. Bur.*, No. 10, 1947, 211).

POTAMOGETON Linn. (*Potamogetonaceae*)

D.E.P., VI(1), 331; Fl. Br. Ind., VI, 565; Subramanyam, 93.

A large genus of aquatic herbs distributed in the temperate and tropical regions of the world. About 15 species are recorded in India.

The plants of the genus are slender herbs with creeping rootstocks, found nearly throughout India, inhabiting freshwater tanks, pools, ponds and canals, often growing gregariously. They bear submerged or floating leaves and minute flowers in axillary spikes. The fruits are small and indehiscent.

The plants are of little economic value; they serve at the most as food for some wild water-fowls and ducks and as shelter and shade for fishes. Often they support growth of algae and small animals which indirectly provide food for game fishes. Sometimes they are said to help in softening water by removing lime and carbon dioxide (Fassett, 348–49, 357–58).

P. crispus Linn., *P. lucens* Linn. and *P. natans* Linn. are said to be gathered and used as fodder in Kashmir and Ladakh. The rootstocks of *P. pectinatus* Linn., *P. gramineus* Linn. and *P. filiformis* Pers. are said to contain starch. An analysis of the plants of *P. pectinatus* Linn. and *P. perfoliatus* Linn. showed the following composition respectively (dry basis): crude protein, 7.6–15.2, 6.6–13.5; fat, 0.6–1.9, 0.6–1.3; N-free extr., 45.5–52.0, 45.5–59.2; cellulose, 19.1–23.7, 13.8–15.9; and mineral matter, 16.2–18.3, 12.3–31.5%. They also contain 10.5 and 11.3 mg./100 g. of

carotene respectively (Stewart, 241–42 ; Fassett, 357–58 ; *Chem. Abstr.*, 1961, **55**, 11689).

The leaves of two species, *P. natans* and *P. crispus*, are reported to contain a pigment rhodoxanthin. The plants of *P. natans* are said to be useful in homoeopathy (Karrer, 739 ; Hoppe, 730).

Potato — *see* **Solanum**

Potato, Air or Karen — *see* **Dioscorea**

Potato, Country — *see* **Coleus**

Potato, Sweet — *see* **Ipomoea**

Potato Yam — *see* **Dioscorea**

POTENTILLA Linn. (*Rosaceae*)

A large genus of herbs or rarely shrubs distributed chiefly in the North temperate zone. Nearly 50 species occur wild in India, and some exotics have been introduced into the gardens.

Potentillas, commonly known as Cinquefoils, are suitable for borders and rock gardens. They thrive in heavy soils. Propagation is done through seed, cuttings, or division of rootstocks. Potentillas are easily hybridized and fine strains of double blooms have been obtained (Bailey, 1947, III, 2772 ; Chittenden, III, 1655).

P. anserina Linn. SILVERWEED

Fl. Br. Ind., II, 350 ; Kirt. & Basu, II, 973 ; Stella Ross-Craig, pt VIII(1), Pl. 35.

A rather slender, perennial herb, up to 30 cm. high, distributed in the western Himalayas at altitudes of 2,100–4,800 m. Rootstocks very short, slender ; leaves pinnate : stolons up to 30 cm. long arise from the leaf axils : leaflets 12–24, linear-oblong to narrowly-lanceolate ; flowers large, solitary, golden yellow ; achenes numerous, smooth.

The herb is considered to possess astringent, spasmolytic, tonic and vulnerary properties. It is prescribed in the form of a tea, or in wine, in diarrhoea, leucorrhoea, kidney stones, arthritis and cramps. An infusion of the herb is used to stop excessive and painful flow of menses and also for intestinal troubles. The rootstocks are eaten in times of scarcity (Hoppe, 730 ; Wren, 279 ; Uphof, 294 ; *Chem. Abstr.*, 1940, **34**, 7010 ; Steinmetz, I, 47).

The herb contains tannins (2–10%), quercitrin, quercetin, tormentol (a triterpene ester), an essential oil (0.28%), and vitamin E (198 p.p.m. in green parts, on dry basis). The tannins are of pyrogallol and pyrocatechol nature, the maximum amounts occurring in the rootstocks (up to 17.5%, on dry basis). The presence of a spasmolytic principle, a muscle contracting principle and a heat activating substance is reported ; the first one is probably a glycoside or a mixture of glycosides. The spasmolytic and muscle contracting principles are found in such low quantities that the utilization of the herb for these purposes is, perhaps, not possible (Hoppe, 730 ; *Chem. Abstr.*, 1961, **55**, 11764 ; 1943, **37**, 499 ; 1954, **48**, 3434 ; 1949, **43**, 9383 ; 1964, **60**, 9594 ; 1955, **49**, 6481 ; Chopra, Nayar & Chopra, 202).

P. fruticosa Linn.

D.E.P., VI(1), 332 ; Fl. Br. Ind., II, 347 ; Blatter, I, Pl. 21, Fig. 8.

PUNJAB—*Merino, spang jha* ; LADAKH *Penma, pinjung* ; LAHUL—*Spang-cha*.

A much-branched, silky, robust shrub, up to 1.5 m. high, found in the Himalayas from Kashmir to Sikkim at altitudes of 2,400–4,800 m. Leaves pinnate,

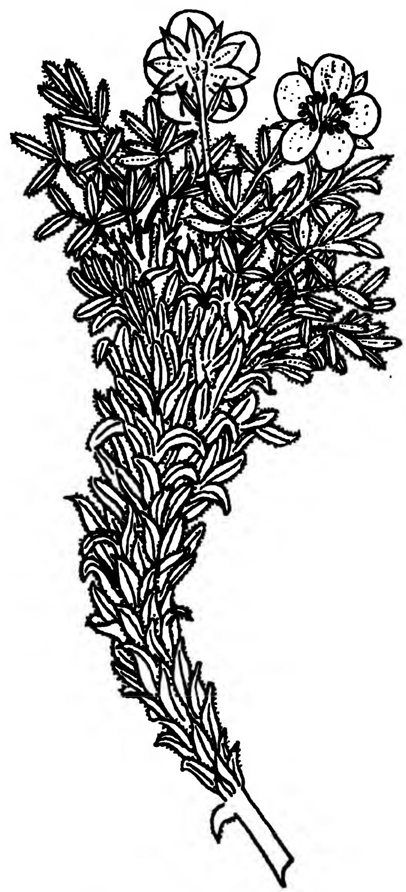


FIG. 85—POTENTILLA FRUTICOSA—FLOWERING BRANCH

crowded: leaflets 3–7, elliptic, oblong-lanceolate or linear-lanceolate; flowers bright yellow, solitary or in terminal, few-flowered cymes; achenes numerous, minute, with long hairs.

This species is very variable and includes several varieties; some of the varieties ascend up to 5,250 m. It has been found that the North American plants of this species are diploid, while the European and, possibly, the Asiatic ones are tetraploid (Bowden, *J. Arnold Arbor.*, 1957, **38**, 381).

The shrub is astringent and antispasmodic. Its medicinal uses are more or less similar to those of *P. anserina*. The dried leaves are used as a substitute for tea (Kirt. & Basu, II, 974; Hocking, 180).

The shrub is reported to be browsed by sheep and cattle. Analysis of the vegetative parts (from Canada) gave: dry matter, 92.2; protein, 13.0; fat, 3.5; crude fibre, 19.2; mineral matter, 4.7; calcium, 0.73; and phosphorus, 0.18%; carotene, 3.74 mg./100 g. The leaves contain ursolic acid (0.7%) and another triterpene (m.p. above 295°), the total triterpene content being 2 per cent (Johnston & Bezeau, *Canad. J. Pl. Sci.*, 1962, **42**, 105; *Chem. Abstr.*, 1955, **49**, 11959).

P. reptans Linn.

D.E.P., VI(1), 332; Fl. Br. Ind., II, 356; Stella Ross-Craig, pt VIII(1), Pl. 34.

A perennial herb, up to 15 cm. high, with procumbent rooting stems, up to 90 cm. long, arising from a rosette of leaves. It is found in Kashmir. Rootstocks woody: leaves digitately compound: leaflets usually 5, obovate or oblanceolate, 2.5–5.0 cm. long; flowers usually solitary, axillary, golden yellow; achenes many, smooth, dark brown.

The herb is considered to possess astringent, febrifugal and haemostatic properties. An infusion of it is given in diarrhoea; it is also used externally as an astringent lotion. The rootstock possesses anti-diarrhoeic and depurative properties. The fruits are edible (Kirt. & Basu, II, 975; Wren, 123; *Chem. Abstr.*, 1950, **44**, 2707; Nadkarni, I, 1008; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 99).

The herb contains in all its parts tannins (8.82%), ellagic acid, flavone, mucilage, gum, pyroxydase and citric, oxalic, tartaric and volatile acids. The presence of a saponin and quercetin-3,7-diglucuronide is indicated in the leaves. The tannin in the rootstocks is stated to be similar to that of American Rhatany (*Krameria triandra*) root. The rootstocks also contain tormentol (*Chem. Abstr.*, 1950, **44**, 2707; Materiae Rudes Plantarum, VII, 43; Harborne, *Phytochemistry*, 1965, **4**, 107).

P. argyrophylla Wall. ex Lehm. (U. P.—*Kamlua*) is a perennial, tomentose herb, 30–60 cm. high, with digitately compound leaves and yellow flowers, commonly found in the Himalayas from Kashmir to Sikkim, at altitudes of 2,400–4,800 m. The plant is grown for ornament. It is reported to be highly palatable and sheep graze on it. Analysis of two samples (on dry matter basis) from Bugiyal pastures in Uttar Pradesh gave: crude protein, 11.1, 15.3; ash, 6.2, 12.3; calcium, 1.7, 1.1; phosphorus, 0.4, 0.3; and magnesium, 0.5, 0.8%, respectively (Bailey, 1947, III, 2774; Joshi, *Indian vet. J.*, 1966, **43**, 1019).

P. fragarioides Linn. (including *P. leschenaultiana* Ser.) is a robust, perennial herb, up to 30 cm. high, with pinnate leaves and yellow or white flowers in terminal corymbs, distributed in the Himalayas from Kashmir to Bhutan, and in the Nilgiris, at altitudes of 1,200–4,200 m. An infusion of the leaves is reported to possess astringent properties. The rootstocks of the plants from the Nilgiris contain 7.4 per cent of tannin (Kirt. & Basu, II, 976; Hooper, *Agric. Ledger*, No. 1, 1902, 31).

The herb is reported to be highly palatable and on analysis gave (on dry matter basis): crude protein, 12.9; ash, 11.7; calcium, 0.9; phosphorus, 0.2; and magnesium, 0.6% (Joshi, *Indian vet. J.*, 1966, **43**, 1019).

P. fulgens Hook. (Beng. *Bhuitara*; Khasi – *Lyngiangbru*) is an erect, perennial herb, 15–75 cm. high, with a thick rootstock, pinnate leaves and yellow or orange-yellow flowers, distributed in the temperate Himalayas from Himachal Pradesh to Sikkim and in the hills of Assam at altitudes of 1,200–4,350 m. The rootstocks are reported to be used in diarrhoea (Biswas, 51).

P. mooniana Wight (Khasi –*Lyngniang-masi*) is a prostrate or erect herb with yellow flowers, distributed in the temperate Himalayas from Kumaun to Sikkim and in the Khasi hills, at altitudes of 1,200–3,600 m. The rootstocks are chewed with betel leaves (Fl. Assam, II, 204).

P. nepalensis Hook. is a hairy, perennial herb, 30–90 cm. high, with a woody rootstock, digitately compound leaves and dark crimson, purple or bright rose-red flowers, distributed in the Himalayas from Kashmir to Kumaun, at altitudes of 1,500–3,750 m. The herb has long been cultivated in gardens and much hybridized. The rootstocks are considered depurative; their ash is mixed with oil and applied

to burns. Though employed to impart a red colour to wool and wood, they are not the source of true *Ratanjot* (Coventry, Ser. II, 38 ; Hoppe, 731 ; Bole, *J. sci. industr. Res.*, 1961, **20C,** 188).

P. salesoviana Steph. (LADAKH—*Shour*) is a perennial, silky herb, 30–90 cm. high, with pinnate leaves and lilac or white flowers, found in Lahul and Kashmir, at altitudes of 2,400–4,200 m. The fine dust on the underside of the leaves causes violent sneezing. The herb is reported to be browsed by sheep.

P. sericea Linn. is a polymorphic, perennial herb with yellow flowers, found in the western Himalayas from Kashmir to Kumaun and in Sikkim, at altitudes of 2,700–5,000 m., getting smaller in size at higher elevations. It is reported to possess astringent properties (Kirt. & Basu, II, 976).

P. sibbaldii Hallier. f.=*Sibbaldia procumbens* Linn. is a perennial herb, up to 30 cm. high, with digitately compound leaves and pale yellow flowers, found in the Himalayas from Kashmir to Sikkim at altitudes of 4,200–4,800 m. The herb is grazed by sheep. An analysis of the herb (on dry matter basis) gave: crude protein, 9.7 ; ash, 14.4 ; calcium, 1.2 ; phosphorus, 0.1 ; and magnesium, 0.5% (Joshi, *Indian vet. J.*, 1966, **43,** 1019).

P. sundaica Kuntze syn. *P. kleiniana* Wight & Arn. is a diffusely spreading herb with many stems, digitately compound leaves and yellow flowers, found throughout the temperate Himalayas and in the Khasi and Nilgiri hills, at altitudes of 900–2,700 m. The herb is considered astringent and toxic. In Tonkin, the fresh leaves are pounded and applied to abscesses (Kirt. & Basu, II, 976).

P. supina Linn. (GUJ. *Karnali, kanikar*) is a prostrate or sub-erect herb, up to 45 cm. high, with many stems, pinnate leaves and yellow flowers, found throughout the warmer parts of India, ascending to an altitude of 2,600 m. The rootstocks are considered to possess astringent, febrifugal and tonic properties. They contain 7 per cent tannin (Rama Rao, 157 ; Wiesner, Lieferung 1, 278).

POTHOS Linn. (*Araceae*)

A large genus of climbing shrubs distributed in tropics of the Old World. About a dozen species occur in India, and about 8 species have been introduced in India and grown in gardens.

Pothos are showy evergreen climbers much valued for their ornamental leaves. They are planted in conservatories and look handsome when allowed to climb up pillars, trellises and tree trunks. They root freely at the nodes and can be easily propagated from cuttings. They should be protected from strong sun (Gopalaswamiengar, 362 ; Firminger, 298).

P. scandens Linn.

Fl. Br. Ind., VI, 551.

TAM. *Anaparuga* ; KAN.—*Adkebiluballi* ; MAL.—*Farisa, paruvakodi.*

A much-branched climber found on walls and tree trunks in Bihar, Orissa, North Bengal, Lushai hills, Manipur, in western ghats Konkan southwards, and Andaman and Nicobar Islands. Leaves very variable, obovate, elliptic or lanceolate ; spathe cymbiform, cuspidate, green : spadix yellow, stipitate, globose, ovoid or shortly oblong ; berries oblong, scarlet.

In the Andaman Islands, the tough stems are used to make belts and necklaces. The root, bruised and fried in oil, is applied to cure abscess. The powdered leaves are applied to smallpox pustules. An infusion of the leaves is used in bath for curing convulsions and epilepsy. The stem cut up with camphor is smoked like tobacco for asthma (Burkill, II, 1804 ; Rama Rao, 428 ; Kirt. & Basu, IV, 2625 ; Burkill & Haniff, *Gdns' Bull.*, 1929–30, **6,** 266).

P. cathcartii Schott (LAKHIMPUR—*Hathi denkiya*) is a climber with oblong or ovate-oblong leaves found on tree trunks, banks and rocks in the tropical Himalayas from Kumaun to Bhutan, ascending up to 1,200 m., and in Bihar, North Bengal, Assam, and Khasi, Aka and Lushai hills and Manipur.

In Lakhimpur, the leaves of the plant are fried in ghee and eaten to cure pains [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 360 ; Kirt. & Basu, IV, 2626].

POTTSIA Hook. & Arn. (*Apocynaceae*)

Fl. Br. Ind., III, 652.

A small genus of shrubs distributed in the South-East Asia from India to Malaya and Java. One species occurs in India.

P. laxiflora Kuntze syn. *P. cantonensis* Hook. & Arn. is a large, evergreen, climbing shrub with elliptic-ovate or ovate leaves and pink flowers in axillary or terminal panicles, found in Khasi hills up to an altitude of 1,200 m. In China, the stems are used as cordage. The plant is reported to contain a glucoside the nature of which is yet doubtful [Fl. Assam, III, 257 ; Burkill, II, 1804 ; Bisset, *Ann. Bogor.*, 1955–57, **2**(3), 193].

Poultry — *see* **Livestock,** Supplement to Wlth India—Raw Materials, VI

POURTHIAEA Decne. (*Rosaceae*)

Fl. Br. Ind., II, 382.

A small genus of shrubs or trees distributed in the Sino-Japanese region and Burma. One species with its six varieties occurs in India. Some authors merge this genus with *Photinia* Lindl.

P. arguta Decne. (KHASI—*Dieng-snam-dieng-um; dieng-tyrkhim*) is a very variable shrub or small tree, with lenticellate branches, oblong to lanceolate leaves and small, white flowers, found in the sub-Himalayan tracts of Sikkim and North Bengal, and in the Khasi hills at altitudes of 750-2,000 m. The wood is reddish brown: it seasons well and takes a fine polish. It is suitable for cabinet-work when pieces of sufficiently large size are available (Fl. Assam, II, 224).

POUTERIA Aubl. (*Sapotaceae*)

A large genus of trees and shrubs distributed in tropical and sub-tropical Asia, Africa, America, Australia and the southern Pacific Islands. One species, *P. suavis*, is introduced into India and grown in gardens.

P. suavis Hemsl.

Bailey, 1947, III, 2781; Hemsley, *Kew Bull.*, 1906, 365.

A tree, native of Uruguay and reported to be introduced in Lalbagh Garden, Bangalore. Leaves crowded at the ends of branches, narrow-oblong to lanceolate, coriaceous; flowers very small, in fascicles; fruit about the size of an apricot and of the shape of an apple, yellow and scarlet when mature; seed semi-ovoid, like a large hazel nut.

A few plants are reported to be grown in Lalbagh Garden where they are thriving well. The plants are propagated easily from seeds and bear fruits profusely. The fruits are highly scented and possess a thin edible pericarp; they have an agreeable taste and are easily digestible (Information from the Director of Horticulture in Mysore, Bangalore; Bailey, 1947, III, 2781; Krumbiegel, 67; Hemsley, *Kew Bull.*, 1906, 365).

POUZOLZIA Gaudich. (*Urticaceae*)

A genus of herbs and shrubs distributed in the tropical and sub-tropical regions, chiefly of the Old World. About 15 species occur in India.

P. viminea Wedd.

D.E.P., VI(1), 334; Fl. Br. Ind., V, 581.

ASSAM *Misagi-jollaphang, khojo;* NEPAL—*Chhota kuail, chiple, kulu;* LEPCHA—*Kyingbi.*

A large shrub found in the Himalayas from Chamba eastwards and in the hills of Assam and Manipur, ascending to an altitude of 2,100 m. Bark grey, thin, rough; leaves ovate or oblong-lanceolate, up to 15 mm. long; flowers small, usually monoecious, in dense axillary clusters; achenes ovoid, enclosed in chaffy perianth.

The leaves are eaten as a vegetable, and are considered to possess stomachic properties. An infusion of the roots is reported to be used for haemorrhage. The bark yields a fibre used for cordage and fishing nets. Wood (wt., 593 kg./cu.m.) is used as fuel [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 12; Uphof, 294; Burkill, II, 1804; Gamble, 659; Gupta, 458].

P. zeylanica (Linn.) Benn. syn. *P. indica* Gaudich.; *P. tuberosa* Wight

D.E.P., VI(1), 334; Fl. Br. Ind., V, 581-82.

TEL. *Eddu, eddu-mutte dumpa;* TAM. & MAL. *Kallurki.*

A very variable, erect or procumbent, perennial herb, up to 1.8 m. high, found throughout India up to an altitude of 2,100 m. and often occurring as a weed. Leaves ovate-lanceolate, up to 7 cm. long; flowers small, greenish, in axillary, androgynous clusters; achenes broadly ovoid, minute.

The roots sometimes become tuberous and are eaten raw, boiled or roasted. Leaves are occasionally eaten as a vegetable; it is believed that the use of this vegetable leads to the expulsion of worms. The leaves are also used as a vulnerary and as a cicatrizant for gangrenous ulcers. Juice of the leaves or their decoction is given as a galactagogue. A poultice of the herb is applied to sores and boils, and to relieve stomach-ache (Burkill, II, 1805; Brown, III, 182; Rama Rao, 388).

P. hirta Hassk.=*Gonostegia hirta* (Blume) Miq. (BENG. *Pathura harjora;* LEPCHA *Chiple*) is a sub-erect or decumbent herb, up to 90 cm. high, with oblong-lanceolate leaves and tuberous roots found in the Himalayas from Chamba eastwards to Sikkim and in the hills of Assam and Manipur, up to an altitude of 2,100 m.; it has also been recorded from Bihar and the Nicobar Islands. The roots are reported to be used for the treatment of fractures and dislocation of bones. They are also employed in the preparation of a hair wash (Biswas, 82; Fl. Assam, IV, 291).

P. pentandra Benn.=*Gonostegia pentandra* (Roxb.) Miq. (SADRI & ORAON—*Karchalatti;* MUNDARI—*Sukuripota*) is a very variable stout herb, up to 90 cm. high, with oblong-lanceolate leaves found

throughout the tropical Himalayas from Kangra eastwards, ascending to an altitude of *c.* 1,000 m. and in Khasi and Naga hills in Assam, West Bengal, Bihar, Orissa and parts of the Deccan Peninsula. It is reported to yield a fibre useful for cordage. The herb is crushed in *karanja* oil, obtained from the seeds of *Pongamia pinnata,* and applied to the body as a refrigerant (Bressers, 127).

P. wightii Benn. (TAM.—*Thovaga* ; MAL.—*Parakozhuppa*) is a very variable usually tall and robust herb found in the Deccan Peninsula. It is sometimes used as a substitute for soap (Rama Rao, 389).

PRANGOS Lindl. (*Umbelliferae*)

A genus of perennial herbs distributed in the Mediterranean region, and western and central Asia. One species occurs in India.

P. pabularia Lindl.

D.E.P., VI(1), 334 ; Fl. Br. Ind., II, 695 ; Kirt. & Basu, Pl. 482A.

HINDI—*Komal.*

KASHMIR—*Kurungas, fetrasalium.*

A tall perennial herb, 100–200 cm. high, found in Kashmir and Himachal Pradesh at altitudes of 1,800–4,000 m. Leaves compound, much dissected into a number of filiform segments ; flowers yellow, in compound umbels ; fruits oblong, 6–18 mm. long with ridges 3 mm. broad.

P. pabularia is held in considerable repute in indigenous medicine for its roots and fruits. The plant is fairly well distributed in Jammu and Kashmir, and in the Bashahr region of Himachal Pradesh. It favours well exposed and dry sandy localities. The plant flowers during the month of June, and the fruits are ready for collection in August–September when they are just mature ; over-ripe fruits are liable to shed. The umbels are generally cut by hand, dried and threshed in the sun for two or three days, and the fruits are then packed in coarse cloth bags. The roots are usually collected in October–November when the aerial portions have dried up. The dried-up remains of the stem and leaf bases form a dense hairy growth around the upper portions. Older roots which show large number of such protruberances on the upper portion are preferred. The roots take about 12–15 days to dry in the sun, when about 70–80 per cent of their moisture is removed. The roots when mature measure up to 40 cm. They are sliced into small pieces to facilitate early drying. About 20–30 tonnes of dry roots can be collected from the growing areas annually (Sarin & Kapoor, *Perfum. essent. Oil Rec.*, 1963, **54,** 437).

The roots of *P. pabularia* have a bitter taste and fragrant odour ; they are burnt as incense by the local people. The roots are considered diuretic, and are used as external application in the treatment of itches. An infusion of roots is given for indigestion and in irregularity of menses (Sarin & Kapoor, loc. cit. ; Kirt. & Basu, II, 1213 ; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7,** 99).

On steam distillation, the dried roots from Kashmir gave 0.75 per cent of a light yellow essential oil, with a characteristic odour and having the following properties: sp. gr.$^{20°}$, 0.8635 ; $[\alpha]_D^{20°}$, 12.2° ; n_D, 1.4800 ; acid val., 0.34 ; ester val., 31.7 ; ester val. after acetylation, 33.6 ; sol. in 11 vol. of 80% alcohol ; esters (as geranyl acetate), 11.1 ; total alcohol (as geraniol), 9.5 ; free alcohol (as geraniol), 0.5 ; and carbonyl content, >1.5%. The oil contained *d*-myrcene (over 50%), *dl*-α-pinene, β-pinene, camphene, terpenolene, dihydrocuminylic ester, osthol,

FIG. 86—PRANGOS PABULARIA — a and c, FLOWERING AND FRUITING BRANCHES ; b, ROOTS

TABLE 1—COUMARIN COMPOUNDS ISOLATED FROM THE ROOTS OF PRANGOS PABULARIA*

	Mol. formula	m.p.
Peucedanin	$C_{15}H_{14}O_4$	109°
Oxypeucedanin	$C_{16}H_{14}O_5$	142–43°
Hydroxypeucedanin	$C_{15}H_{14}O_5$	109°
Prangolarin [(+) oxypeucedanin]	$C_{16}H_{14}O_5$	104–05°
Imperatorin	$C_{16}H_{14}O_4$	99–100°
Prangenin (oxyimperatorin)	$C_{16}H_{14}O_5$	114–15°
Prangin	$C_{16}H_{16}O_6$	174–75°
Prangenidin (alloimperatorin)	$C_{16}H_{14}O_4$	228–29° (decomp.)
Osthol	$C_{15}H_{16}O_3$	83–84°
Aviprin (oxypeucedanin hydrate)	$C_{16}H_{16}O_6$	135–36°
Komalin (heraclenin hydrate)	$C_{16}H_{16}O_6$	128–29°
Xanthotoxol	$C_{11}H_6O_4$	245°

* Gupta *et al.*, *Indian J. Chem.*, 1964, **2**, 464 ; *Chem. Abstr.*, 1956, **50**, 15743 ; 1961, **55**, 22281 ; 1962, **57**, 12869 ; Ghoshal *et al.*, *Chem. & Ind.*, 1963, 1430.

sesquiterpenes and an azulene (Chaudhary & Handa, *Indian Oil & Soap J.*, 1959–60, **25**, 397).

The roots are a good source of coumarin compounds (Table 1), their highest concentration being found at the flower-bud stage of the plant. Coumarins are also present in the leaves, umbels, and fruits. Osthol (7-methoxy-8-*iso*pentenyl coumarin) which occurs in the dried roots up to the extent of 3.6 per cent, has been found to be a potent respiratory and circulatory stimulant in experimental animals. Its respirotonic effect was more marked than that of coramine, leptazol and caffeine. It caused a rise of arterial blood pressure in dogs, rabbits and rats but had a depressor effect in cats. It has been shown to be free from any local toxic action (*Chem. Abstr.*, 1962, **57**, 3785 ; Gupta *et al.*, *Indian J. Chem.*, 1964, **2**, 464 ; Gupta *et al.*, *Indian J. Pharm.*, 1960, **22**, 235 ; Jamwal *et al.*, *Arch. int. Pharmacodyn.*, 1962, **138**, 400 ; 1964, **147**, 351 ; Gulati *et al.*, ibid., 1966, **163**, 481 ; Gupta & Jamwal, *Indian J. med. Res.*, 1967, **55**, 241).

The fruit (seed) possesses a pleasant smell and a sharp sweet taste. It is used as carminative, laxative, diuretic, aphrodisiac, stimulant, stomachic, and tonic to the liver ; it promotes expulsion of foetus. In Kashmir, a decoction of the fruit is given as antiseptic wash to cure rot (liver-fluke) in sheep (Kirt. & Basu, II, 1213–14 ; Parsa, loc. cit.).

The coumarins isolated from the fruits are osthol (2.8%), prangolarin, imperatorin, prangenidin (allo-imperatorin), bergapten, and oxypeucedanin. The fruits also contain an essential oil, a fatty oil (6.5%), resin, quercetrin, and alkaloids (0.2%) including prangosine ($C_{15}H_{15}NO_3$, m.p. 132°). The dried umbels contain osthol (0.8%), imperatorin, *iso*imperatorin, bergapten, and heraclenin [(+)-prangenin] (Gupta *et al.*, *Indian J. Chem.*, 1964, **2**, 464 ; *Chem. Abstr.*, 1965, **63**, 15113, 3309 ; 1959, **53**, 3606).

The plant is characterized by a strong spicy odour. The fresh plant yields 2 per cent of an essential oil containing myrcene (48%), α-pinene (4%), borneol and dihydrocuminol both free and as acetates (17.5%), resinous residue (28%), and traces of camphene and an unidentified aldehyde (Sarin & Kapoor, loc. cit. : *Chem. Abstr.*, 1940, **34**, 7529).

The plant is considered a valuable fodder for goats and sheep particularly in Ladakh. In parts of the U.S.S.R., hay made from the plant is highly valued as a cattle feed. Analysis of the plant cut at the bud formation stage gave the following values (dry basis): protein, 10.4 ; fat, 3.5 ; N-free extr., 54.4 ; crude fibre, 22.6 ; and ash, 7.0% (Sarin & Kapoor, loc. cit. ; Materiae Rudes Plantarum, II, 295–96).

The plant is considered poisonous to lower animals ; a decoction of the plant destroys snails. The young leaves and flowers are used by local people as insect-repellent in paddy godowns. Horses fed on the fruits are said to have suffered severely from inflammation of the eyes and even from temporary blindness (Sarin & Kapoor, loc. cit.).

Prase — *see* **Quartz and Silica**

PRATIA Gaudich. (*Campanulaceae ; Lobeliaceae*)

A genus of herbs distributed in tropical Asia, Australia, New Zealand and South America. Two species occur in India.

P. nummularia Kurz syn. *P. begoniifolia* Lindl.

Fl. Br. Ind., III, 422.

LUSHAI—*Chaokathi*.

A small, trailing and rooting herb found in the Himalayas from Nepal to Bhutan, and Khasi, Aka and Lushai hills in Assam, in the western ghats (Shembaganur), and in South India at altitudes of 600–2,100 m. Leaves cordate-ovate, denticulate ; flowers green marked with pink ; berry ellipsoid, black ; seeds ellipsoid, compressed, smooth.

The plant is used for dysentery and asthma. A decoction of the plant is given as a diaphoretic. The leaves are pounded and used for treating sprue in Java (Biswas, 65; Cheo, *Bot. Bull. Acad. sinica*, 1947, **1**, 298; Burkill, II, 1805).

The juice from the herb coagulates blood and stops excessive bleeding (Rao Rolla, *Bull. bot. Surv. India*, 1963, **5**, 165).

PRAWNS, SHRIMPS AND LOBSTERS (Phylum *Arthropoda*, class *Crustacea*, subclass *Malacostraca*, order *Decapoda*, suborder *Macrura*)

Alcock, 1906, 1–55; Patwardhan, *Indian zool. Mem.*, 1957, **6**, 1–112.

A considerable part of the fisheries in India is constituted by the crustaceans, such as prawns, shrimps and lobsters. Prawns and shrimps, which belong to the group *Natantia*, are similar in appearance; shrimps, however, are smaller in size. Lobsters are robust, heavily armoured creatures; they are exclusively marine and are included under the group *Reptantia*. All the three decapods have elongated bodies divisible into two easily recognizable parts, viz. the cephalothorax and the abdomen. The cephalothorax is formed by the fusion of the head and thorax, and is made up of not less than thirteen segments, five in the head and eight in the thorax. The abdomen is composed of six distinct segments with a tail piece or telson behind the last segment. Each of these segments generally carries a single pair of appendages, which are useful in the normal functioning of the body. Head appendages are two pairs of antennae, sensory in function, and a pair of mandibles and two pairs of maxillae, used in capturing and masticating food. Thorax possesses three pairs of maxillipedes, probably used for holding the prey, and five pairs of walking legs for crawling. Abdominal appendages are adapted for swimming. Sexes are separate and the reproductive organs are mainly situated in the cephalothorax.

OCCURRENCE AND DISTRIBUTION

Prawns

Indian commercial prawns are of two kinds, viz. penaeid type belonging to the family *Penaeidae* (Section *Penaeidea*), and palaemonid type belonging to the family *Palaemonidae* (Section *Caridea*). The majority of prawns contributing to the valuable prawn fishery of the country—marine, estuarine and backwater—belong to the family *Penaeidae*.

PENAEIDAE

Prawns belonging to this family are common in the sea and in brackish water environments, such as estuaries and backwaters. They are quite abundant in the Indo-Pacific region, many preferring shallow, inshore waters, where the bottom is largely muddy and often containing large quantities of organic detritus. Some of the smaller species, e.g. *Metapenaeus dobsoni* (Miers) and *Parapeneopsis* spp. are most abundant in waters seldom exceeding 10–15 fathoms (18–27 m.) in depth. The association of these inshore prawns with mud banks along the coast of Kerala is taken advantage of by fishermen of this region who catch every year hundreds of tonnes of these prawns from the coastal waters. Some penaeid species, such as *Metapenaeopsis coniger* Wood-Mason prefer deep waters.

In penaeid prawns the carapace is drawn out into a median, forwardly projecting rostrum and the eye-stalks are two- or three-jointed; first abdominal segment overlaps the second at the sides; gills are completely branched; the first three pairs of walking legs are chelate and successively increase in length. In abyssal forms the eyes may be frequently reduced or may be absent altogether.

Three important genera of penaeid prawns known from Indian waters and constituting the prawn fisheries are: *Penaeus* Fabr., *Metapenaeus* Wood-Mason, and *Parapeneopsis* Wood-Mason.

Penaeus Fabr.—The rostrum is serrated on both the edges; a gill is attached to the body wall on the last thoracic somite; exopodites are present on all, or all but the last pair of thoracic legs. Largest prawns caught from the Indian seas belong to this genus.

P. indicus Milne-Edwards

Beng.—*Chapda chingri*; Mal.—*Vella-chemmeen, naran-chemmeen.*

The body is somewhat laterally compressed and when alive the prawn is rather white and translucent with a large number of brown, grey or green dots over the carapace and abdomen. The antennae and tips of the appendages are pink. It is fairly large in size, growing to about 20 cm. in length, and occurs commonly along the entire coast-line of the country, in coastal waters, estuaries, coastal lakes and backwaters.

P. monodon Fabr. syn. *P. carinatus* Dana (de Man)

Beng.—*Bagda chingri*; Mal.—*Kara-chemmeen.*

Seafood Canners' & Freezers' Ass. India

PRAWNS—COLLECTION OF PENAEUS INDICUS

Adult prawns of this species are deeply pigmented, varying from olive green to deep bluish grey, with darker bands across the abdomen. The outer surface of the stalks of the pleopods is bright lemon yellow in colour. Young prawns (*c.* 5–8 cm.) are pale grey with dark green mottling and indistinct yellow patches on the pleopods. Still younger ones (*c.* 2.5 cm. or less), very slender in build, are deeply mottled with dark grey and dull green ; probably the colouration is a protective adaptation for life among the weeds.

This species is the largest of Indian penaeid prawns, growing to a size of about 30 cm. and weighing over 142 g. Though found all along the Indian coast, it is not caught in large numbers. Juveniles of this species are common in waters ranging up to 12 fathoms (*c.* 22 m.) in depth, whereas adults are known to occur up to about 90 fathoms (*c.* 164.5 m.) off the coast.

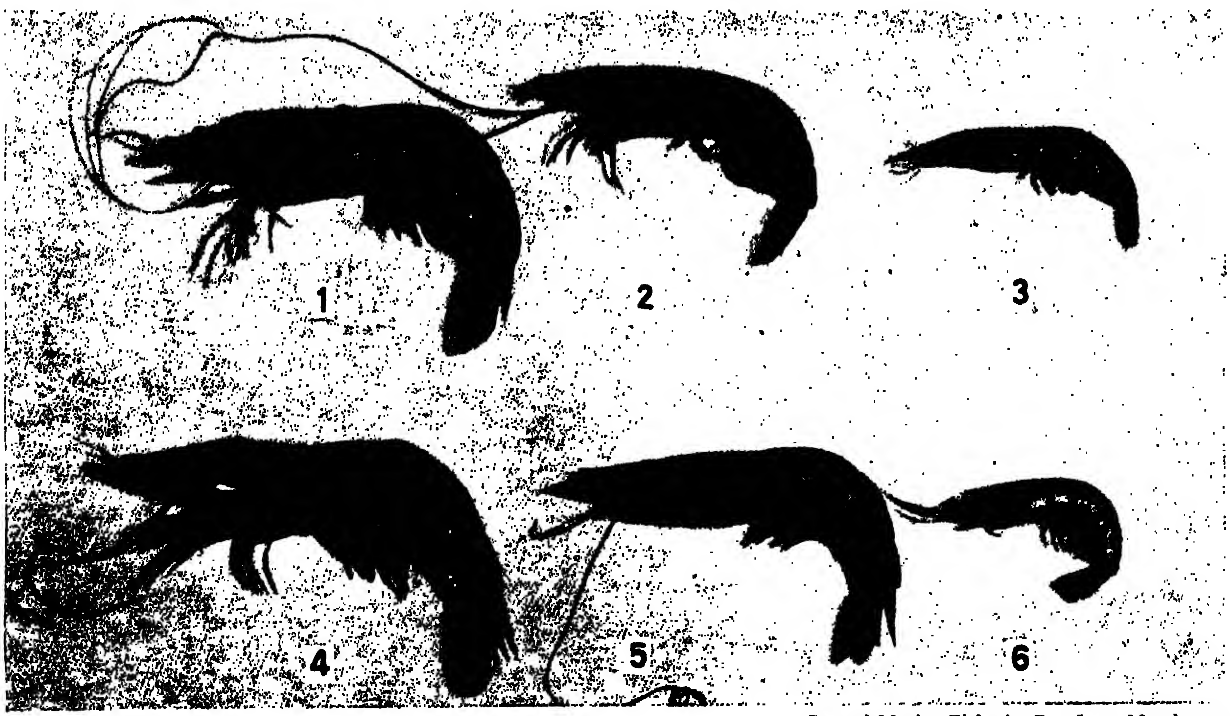
Metapenaeus Wood-Mason—The rostrum is toothed on its dorsal edge only. No gill is present on the last thoracic somite. Prawns belonging to this genus are comparatively smaller than those of the preceding genus, but are captured in much larger numbers. Four species, listed below, are prominent in the fisheries at different centres.

M. affinis (Milne-Edwards)
MAL.—*Kazhanthan-chemmeen.*

The rostrum is curved in this species, and the last pair of thoracic legs in both sexes, when stretched forwards, project beyond the tips of the antennal scale. In respect of size and a few other characters it resembles *M. monoceros* (Fabr.), described below. It occurs along both the coasts, but is not very common in the backwaters and estuaries.

M. brevicornis (Milne-Edwards)
BENG.—*Dhanbone chingri.*

The rostrum in this species is short, rarely reaching to the middle of the second joint of the antennular peduncle. Fully grown forms rarely exceed 13 cm. in length. It is the commonest penaeid species of West Bengal, found in vast numbers in the inundated paddy fields during the rainy season. It is found, though in smaller numbers, on the Bombay coast also.



Central Marine Fisheries Res. Inst., Mandapam

FIG. 87—PRAWNS (DIFFERENT TYPES ×0.33) : 1, Penaeus indicus ; 2, Metapenaeus affinis ; 3, Metapenaeus dobsoni ; 4, Penaeus monodon ; 5, Metapenaeus monoceros ; 6, Parapeneopsis stylifera

M. dobsoni (Miers)

Mal.—*Thelli-chemmeen, poovalan-chemmeen.*

The body is covered with tomentum which is more patchy and less coarse than that of *M. monoceros.* It grows up to a length of about 13 cm., and occurs commonly on both the coasts in waters seldom exceeding 10–15 fathoms (*c.* 18–27 m.) in depth. It is abundant in estuaries and backwaters.

M. monoceros (Fabr.)

Beng.—*Koraney chingri, honye chingri;* Mal.—*Choodan-chemmeen.*

The body is covered with a coarse and short tomentum. Fully grown forms reach about 17 cm. in length. The species is distributed along the entire coast-line of the country, and is quite common in estuaries and backwaters during the periods of low salinity.

Parapeneopsis Wood-Mason—The rostrum is toothed on the dorsal edge only. Petaloid exopodites are present on all walking legs. Gills are absent on the last two thoracic somites. *Parapeneopsis* species never ascend into waters subject to great changes in salinity and hence are hardly ever caught from estuaries and backwaters. Their entire life is spent in the sea. The three main species occurring in Indian waters seldom exceed 20 fathoms (36.5 m.) in depth, and are commercially important.

P. maxillipedo Alcock

This species is similar in size to *P. stylifera*, described below, and is generally caught along the Bombay coast, though its occurrence on the east coast has also been recorded.

P. sculptilis (Heller)

The rostrum is of the same shape as in *P. stylifera* but shorter; in the adult male the distal styliform part is often lost. There are no lateral marginal spines on the telson. This species grows up to a length of about 14 cm. It is distributed along both the coasts but is commercially caught only along the Bombay coast and in the estuaries of the Hooghly river in West Bengal.

P. stylifera (Milne-Edwards)

Mal.—*Karikkadi-chemmeen.*

It is characteristically reddish brown in colour. The presence of a number of small spines on either side of the pointed extremity of the telson further distinguishes this species from others. Adult prawns reach a length of about 13 cm. Its distribution is mainly on the west coast, and it is caught in large numbers along the Kerala coast during December–May. A variety of this species, viz. *coromandelica* Alcock, with two spines on each side of the telson, has also been recorded from various places along the east coast.

PALAEMONIDAE

Prawns belonging to this family include not only marine and brackish water species, but also freshwater species. In these prawns there are three flagellae in the first antennae and the first and second pairs of walking legs are chelate, the second pair being larger than the first.

Marine prawns of this type belong to the genus *Palaemon* Weber, while freshwater prawns, which are of greater value, belong to the genus *Macrobrachium* Bate.

Palaemon Weber—It includes a large number of species which are rather small, seldom exceeding 10 cm. in length, and generally marine in habit; a few species, however, are also quite common in estuaries and other brackish waters. *P. fluminicola* Kemp lives preferably in brackish water, but is reported to ascend the river Ganga to a distance of about 1,125 km.

P. styliferus (Milne-Edwards)

Beng.—*Ghora chingri.*

This species inhabits both marine and brackish waters and contributes substantially to the prawn fishery of the Gangetic delta and the Bombay coast. It seldom exceeds 5 cm. in length.

P. tenuipes (Henderson)

This species is easily recognizable by the long and slender fourth and fifth pairs of walking legs. Its habitat is similar to that of *P. styliferus* and it is caught in large numbers off the Bombay coast.

Macrobrachium Bate—It includes several species of freshwater prawns which are widely distributed all over India in rivers, lakes and ponds, and account for a considerable part of the commercial catches. Though they are essentially freshwater in habitat, some species migrate into brackish water, when the salinity is low, for liberating eggs and larvae. Further development takes place in such environments. The young prawns return to freshwater again and reach maturity there. The economically important species of the genus include the following.

M. idae (Heller) is common in Kerala backwaters during September–December.

M. malcolmsonii (Milne-Edwards) is very common in the Chilka lake in Orissa, Hooghly estuary, Godavari, and Ganga towards the close of the monsoon and is mainly a freshwater species tolerating brackish water. During this period, mostly the gravid female prawns are caught. They do not exceed 23 cm. in length.

M. mirabile (Kemp) is the most important species, occurring in the upper reaches of West Bengal estuaries.

M. rosenbergii (de Man) syn. *M. carcinus* Fabr.

BENG.—*Golda chingri, mocha chingri*; MAL.—*Konchu.*

This species is somewhat rounded in form. It grows up to about 30 cm. in length. Though a freshwater form, it is accustomed to live in brackish water also, where it is reported to migrate for breeding purposes. In the backwaters of Kerala, berried females of this species are quite common during September–November. Because of its large size and easy availability, this species is much in demand for preservation and export.

M. rudis (Kemp)

BENG.- *Goda chingri.*

This is a common species, stout in build, found in some parts of West Bengal during August–October, when a large number of females, carrying eggs, are caught. It is also found in the Chilka lake in Orissa and occasionally in other brackish waters.

M. scabriculum (Heller) is a purely freshwater species.

Several species of *Macrobrachium*, along with penaeids, form an important fishery in the lakes and backwaters along the Indian coast during the rainy season when the salinity of the water is low; later during the summer months the catches consist almost entirely of penaeids.

HIPPOLYTIDAE

Prawns belonging to this family possess a long rostrum. The first pair of walking legs is short, robust and chelate; the second pair, though chelate, is more slender, with its carpus subdivided into two to several joints. Only one species, viz. *Hippolysmata ensirostris* Kemp, about 5 cm. in length, is of some economic importance, as it is quite common in the commercial catches along the Bombay coast.

SHRIMPS

Shrimps are comparatively smaller in size than prawns and have elongated bodies and slender limbs; fourth and fifth pairs of legs are either reduced or absent. Indian commercial shrimps belong to the families *Sergestidae* (Section *Penaeidea*) and *Atyidae* (Section *Caridea*).

SERGESTIDAE

Commercially important shrimps of this family belong to the genus *Acetes* Milne-Edwards. These shrimps seldom exceed 2.5 cm. in length and are found in swarms in the plankton of coastal waters, particularly the Bombay coast, where the annual catch amounts to several hundred tonnes. Some common Indian species of this genus are *A. erythraeus* Nobili, *A. indicus* Milne-Edwards, *A. japonicus* Kishinouye and *A. sibogae* Hansen. Besides their value as an article of human diet, they are one of the chief foods of some of the fishes of economic importance; the phosphorescent shrimps belonging to the genera *Lucifer* Thompson and *Sergestes* Milne-Edwards are also eaten by the fish.

ATYIDAE

In shrimps belonging to this family the first and second pairs of walking legs have highly mobile chelae, bearing spoon-shaped fingers tipped with brushes of long setae. They are small, less than 2.5 cm. in length, and found in freshwater or brackish water. *Caridina gracilipes* de Man (BENG.—*Ghusha chingri*) is a familiar shrimp of this family which is caught in West Bengal and marketed along with other shrimps.

MUD-SHRIMPS

They are so called because of their superficial resemblance to commercial shrimps, but are not true prawns or shrimps, as they belong to an entirely different order *Mysidacea.* Mud-shrimps inhabit marine or brackish water and are sometimes also called opossum-shrimps because of the presence of brood pouches. The important species include *Macropsis orientalis* Tattersall, *Potamomysis assimilis* Tattersall, and *Gnathophausia ingens* (Dohrn); the last species is the largest member of the order, reaching a length of about 16 cm. They are cheap and are eaten in West Bengal.

BRINE-SHRIMPS

The occurrence of brine-shrimps of the genus *Artemia* Leach (Subclass *Branchiopoda*, order *Anostraca*) in Indian waters was discovered in 1951, when a large number of fully developed forms

were caught from salt-pans at Vadala on the outskirts of Bombay. They are tiny, about one cm. in length, and cherry-red in colour when fully grown. Younger forms are pale whitish. Well marked sexual dimorphism is exhibited in these shrimps, the male having claspers and the female prominent ovisacs. Brine-shrimps are capable of thriving in waters of extreme salinity. Eggs of these shrimps are utilized on a large scale for feeding the tiny fish-fry in different parts of the world. Adult shrimps are fed to large aquarium fish.

LOBSTERS

Lobsters, particularly the spiny lobsters or rock lobsters, inhabit the inshore waters of the sea, preferring regions with hard rocky bottoms. The more common ones are usually caught from comparatively shallow waters, though a number of species prefer deeper regions of the sea. Lobsters of the families *Palinuridae*, *Scyllaridae* and *Eryonidae* are found in the catches from Indian waters.

PALINURIDAE

In lobsters of this family the carapace is subcylindrical and eyes are not enclosed in orbits. The second pair of antennae have long whip-like flagella. The walking legs are more or less alike and none of them, except sometimes the last pair in females, is chelate. The first abdominal segment is devoid of any appendage. Species of the genus *Panulirus* White are mainly tropical in distribution, and the important among them are: *P. dasypus* (Milne-Edwards), *P. homarus* (Linn.) syn. *P. burgeri* (de Haan.), *P. ornatus* (Fabr.), and *P. versicolor* (Latr.). They grow up to about 38 cm. in length and weigh 900 g. or more. Different species of *Panulirus* occurring along both the coasts of India contribute to the commercial lobster fishery. A closely related species *Puerulus sewelli* Ramadan, has been recorded from the Gulf of Manaar and the Arabian Sea in waters 38–550 fathoms (70–1,000 m.) in depth.

SCYLLARIDAE

In lobsters belonging to this family the carapace is depressed, eyes are enclosed in orbits, and second antennae are flattened and without the whip-like flagella. *Scyllarus batei* Holthuis and *Thenus orientalis* (Lund) are found in Indian waters at considerable depth, but none of the scyllarids is of any economic importance.

ERYONIDAE

The family is represented in Indian waters by *Polycheles andamanensis* Alcock, which is reported to occur at a depth of about 1,100 fathoms (2,000 m.) in the Bay of Bengal and the Arabian Sea.

REPRODUCTION

Developmental stages of prawns, shrimps and lobsters are almost similar with some variations in the duration and course of metamorphosis. Females of almost all species of penaeid prawns become sexually mature only in the sea and are peculiar in their habit of liberating their eggs in water, the parents taking no further care of them. This habit is shared also by shrimps of the family *Sergestidae*. Other prawns, shrimps and lobsters carry the eggs attached to their abdominal appendages till they hatch out.

The eggs of penaeid prawns and some closely related shrimps are demersal and hatch out as tiny larvae (nauplii) with oval, unsegmented bodies and three pairs of appendages. They moult a number of times, and in 2–3 weeks emerge as small fry (post-larvae) which resemble the adults. The larvae and early post-larvae are planktonic, i.e. they float at or near the surface of the sea, and in the case of most of these prawns, small fry drift towards the coast and eventually pass into estuaries or backwaters. They live at the bottom in these environments for several weeks or months, attaining quick growth, and then migrate back to the sea. These growing young prawns constitute largely the commercial prawn fishery. The post-larvae of *Parapeneopsis stylifera*, however, are not known to leave the sea at any stage; in palaemonid prawns, eggs hatch at a much later stage. Some freshwater prawns and some others living in the depths of the sea do not pass through any free-living larval stages but develop directly from the egg into forms not essentially different from the adult.

The free-swimming larvae of lobsters (spiny lobsters and other related forms) are remarkable for their leaf-like shape and glassy transparency and are popularly known as Glass Crabs. They are well adapted for drifting about and are carried over great distances by oceanic currents. They have an unusually long life, extending in some instances to 6 or 7 months. The changes in shape and structure through which the lobster larvae pass during their metamorphosis are, therefore, more profound and striking than those in most prawns and shrimps.

The occurrence of prawn fry in estuaries and backwaters is being exploited for prawn culture in properly laid out farms.

PRAWN FISHERY

Fishing grounds—While the prawns and shrimps are caught along the entire west coast, their landings on the east coast are mainly limited to the northern part of Andhra coast and a small area near Tuticorin. On the eastern coast, prawns are caught mostly from brackish water lakes, such as Chilka (Orissa), Ennore (Madras), Kolleru and Pulicat (Andhra Pradesh), and estuarine deltaic areas of West Bengal. Apart from the rich prawn fishery of the west coast, a long chain of brackish water lagoons situated close to the coast, with their openings into the sea, serve as excellent prawn nurseries, providing good fishing grounds.

Catches The catches almost always consist of a mixture of different species of prawns and shrimps. Occasionally, during the south-west monsoon period (June-August) inshore waters close to the northern part of Kerala coast are rich in *Penaeus indicus*. This is also true of the fishery near Tuticorin coast. Later catches from areas close to the coast consist mainly of *Metapenaeus dobsoni*. On the south-west coast during January–May *Parapeneopsis stylifera* may dominate in the inshore catches.

The main fishing season in the southern and central parts of Chilka lake is April–August and in the northern parts December–April. In the warmer months, most of the water in Kolleru lake dries up, and during the rainy season, when the lake is full of almost freshwater, the prawn population consists of mostly freshwater species. Later, during March–May, gradually the penaeids become dominant. Fishing season in Ennore lake extends from January to June and *P. indicus* and *Metapenaeus monoceros* are the dominant species. In the deltaic areas of West Bengal, prawns are caught during the post-monsoon months (August–October) and the landings consist of penaeids, such as *M. monoceros* and *M. brevicornis*, together with species of *Palaemon* and *Parapeneopsis*.

The catches through trawling operations in the inshore waters of the west coast are substantially similar to those obtained by fishermen with their indigenous gear. Those obtained from deep-sea areas, beyond the usual fishing grounds, occasionally yield large and mature prawns (*P. indicus* and *M. monoceros*) in appreciable quantities. Landings of marine and brackish water prawns are given in Tables 1 and 2 respectively. No separate figures are available for lobsters; they are included in the data for catches of crustaceans other than prawns and shrimps.

Prawn fishery has been dealt with in detail in the Fish and Fisheries supplement.

TABLE 1—LANDINGS OF MARINE PRAWNS AND OTHER CRUSTACEANS IN INDIA*

(Qty in tonnes)

		Kerala	Maharashtra	Gujarat	Madras	Andhra Pradesh	W. Bengal & Orissa	Mysore	Others	Trawler catches	Total
1960	P	12,583	9,278	4,917	1,872	1,591	803	420	..	295	31,759
	N	23	34,605	365	275	1,003	..	..	..	..	36,271
	O	175	48	25	823	1,423	3	72	1	1	2,571
1961	P	20,393	8,166	3,012	1,819	2,797	1,612	545	1	738	39,083
	N	43	21,744	190	1,008	689	..	10	..	1	23,685
	O	105	46	13	1,311	496	4	58	4	1	2,038
1962	P	29,218	8,076	1,497	2,526	1,305	2,178	2,379	1	1,069	48,249
	N	..	33,725	848	10	373	27	..	..	..	34,983
	O	22	2	4	755	213	..	35	..	..	1,031
1963	P	22,228	5,187	1,698	3,269	3,483	3,776	1,428	1	..	41,070
	N	76	37,482	1,966	101	880	17	..	..	..	40,522
	O	90	14	6	1,058	853	..	39	..	..	2,060
1964	P	35,220	14,301	1,330	3,958	5,229	2,309	1,040	55	..	63,442
	N	..	29,324	832	145	1,205	.	..	..	..	31,506
	O	72	18	..	3,982	468	8	17	..	..	4,565
1965	P	12,472	9,791	3,948	2,636	3,507	2,133	399	960	..	35,846
	N	84	40,412	507	82	330	..	..	..	..	41,415
	O	130	58	..	2,161	9	..	7	27	..	2,392

* Data from Central Marine Fisheries Research Sub-Station, Ernakulam; Fisheries Development Adviser to the Govt. of India, New Delhi.

P– Penaeid prawns. N—Non-penaeid prawns. O—Other crustaceans, mostly crabs and lobsters.

Figures for Madras from 1962 onwards include those for Pondicherry.

TABLE 2—LANDINGS OF BRACKISH WATER PRAWNS IN INDIA*

(Qty in tonnes)

	Hooghly estuary	Chilka lake	Mahanadi estuary
1960-61	612	..	74
1961-62	1,010	881	80
1962-63	797	877	114
1963-64	927	663	55
1964-65	998	700	57

* Data from Central Inland Fisheries Research Institute, Barrackpore.

Landings in Pulicat lake included 206 tonnes during 1964-65.

Fishing nets of boat-seine type are quite commonly used for catching prawns. Cast-net, a variety of wall-net, and other nets are also used in various parts of the country. Substantial quantities of prawns are now being landed by shrimp trawls operated from modern mechanized vessels. Lobsters are caught by small conical nets (bulley-nets), gill-nets and traps along the Bombay coast, where the fishing lasts from November to March. In Kanniyakumari district of Madras State, lobsters are caught in good numbers during December–April and are frozen for export, chiefly to U.S.A. In Kerala, extensive areas of paddy fields are modified into traps for impounding prawns [Fish and Fisheries, Wlth India—Raw Materials, IV, suppl., 118-23; Encyclopaedia Britannica, XIV, 260–61 : XX, 586; Alcock, 1901, 1-286; Chopra, *Proc. Indian Sci. Congr.*, 1943, 1–21 ; Kemp, *Mem. Indian Mus.*, 1915, **5,** 199 : Annandale, *Calcutta Rev.*, 1915, 15 ; Chopra, B. N., 64–66 ; Menon, *Proc. Indo-Pacif. Fish. Coun.*, Sec. 3, 1951, 80 ; Panikkar & Menon, ibid., 1955, 333 : Bhimachar, ibid., 1963, **10,** 124; Panikkar, *Indian J. Fish.*, 1954, **1,** 389 ; Menon, ibid., 1955, **2,** 41 : *J. zool. Soc. India*, 1953, **5,** 153 : *Souvenir, Central Marine Fisheries Research Station, Mandapam*, 1958, 45–50 : Powell, *J. Bombay nat. Hist. Soc.*, 1907-08, **18,** 360 : Panikkar, ibid., 1937–38, **39,** 343 : Chopra, ibid., 1939–40, **41,** 221 ; Kulkarni, ibid., 1952–53, **51,** 951 : Panikkar, *Curr. Sci.*, 1948, **17,** 58 ; Panikkar & Viswanathan, *Nature, Lond.*, 1940, **145,** 108 ; *J. Mar. biol. Ass. U.K.*, 1941, **25,** 317 ; Parry, *J. exp. Biol.*, 1955, **31,** 601 ; Handerson & Matthai, *Rec. Indian Mus.*, 1910, **5,** 277 : Menon, *Seafood Tr. J.*, 1967, **2**(1), 151].

PRESERVATION AND CURING

Prawns intended for local consumption are marketed soon after catching, since they are highly perishable and keep well only for a day or two. Prawns despatched in the fresh state to inland towns are loosely packed between layers of ice. Preservation in ice increases the storage life of prawns to about 15 days. However, storage should be for as short a period as possible to avoid loss of the soluble nutrients and nitrogenous constituents, particularly the free amino acids. The rapid loss of glycine during storage weakens the characteristic flavour of the fresh prawns while the reduction in lysine content is concomitant with the development of malodorous substances. Occurrence of black discolouration (melanosis) during storage is considered an enzymic process and can be minimized by heading the prawns prior to icing. It can also be prevented by the use of chemical inhibitors, such as sodium bisulphite [Fish and Fisheries, Wlth India—Raw Materials, IV, suppl., 121–22 ; Velankar & Govindan, *Indian J. Fish.*, 1959–60, **6,** 306 ; Bose, *Indian Seafoods*, 1964–65, **2**(1), 7].

The common criteria for determining the freshness of prawns are mainly organoleptic, namely texture, odour and flavour. Fresh prawns are dry and crisp to feel and give off an agreeable odour, while the stale ones are moist and clammy, warm and sticky, and possess an objectionable smell. Data on the bacterial load of fresh prawns indicate that the flesh is not sterile and that the heads contain maximum bacterial load. There is a steady increase in the total bacterial count during spoilage and this can be used as an index of the overall quality of the prawn. Also, tests based on estimations such as volatile acid number, have been suggested for assessing the extent of spoilage of prawns (*Marketing of Fish in India, Agric. Marketing Ser.*, No. 126, 1961, 72–73 ; Pillai *et al.*, *Indian J. Fish.*, 1961, **8,** 430 ; Velankar *et al.*, *J. sci. industr. Res.*, 1961, **20D,** 189 ; *Indian J. Fish.*, 1961, **8,** 241).

Curing of fresh prawns and shrimps is done in many ways. The simplest method is to dry the prawns in the sun ; the product is sold as such or after shelling. The prawns are usually cured by boiling them in water till they become reddish brown, and then drying. After two or three days, they are shelled by threshing and winnowing and the resulting dry meat is packed in bags. Prawns processed in this way have only a limited local market, the bulk of the product being exported to Ceylon, Hongkong, Singapore and U.S.A.

A semi-drying process for the preservation of prawns on a large scale has been developed by the Madras State Fisheries Department. In this process, the prawns are boiled in six per cent brine for about

two minutes, shelled, and salted by immersion in saturated brine for 15-30 minutes. After draining off the brine they are dried either in the sun or by means of artificial driers, the flesh being prevented from becoming too hard. The product is packed in alkathene bags and sealed. To store for longer periods, it is packed in tins charged with carbon dioxide. Semi-dried prawns keep well for months and when soaked again in water, taste like fresh prawns. Their nutritive value is not affected by curing.

Smoking of prawns is not popular in India, though in the Kolleru lake area, fresh prawns are sometimes smoked. In parts of Orissa, prawns are preserved by spreading them on mats over a quick but smoking fire. In Malabar, boiled and shelled prawns are pickled in vinegar or weak toddy with condiments and spices.

Prawn canning industry has developed in India during recent years, particularly in Cochin. Till 1958, there was practically no export of canned prawns from India, but for the last few years there has been a growing demand from U.S.A. and other countries.

Freezing of prawns is done at several centres along the coast of India. There are a number of freezing plants at Mangalore, Calicut, Cochin and Trivandrum which are engaged in freezing prawns and lobster tails (entire body behind the head) for export, particularly to U.S.A. The prawns are quick-frozen below $-34°$ in minimum possible time and are given a uniform glazing before being packed [Fish and Fisheries, Wlth India—Raw Materials, IV, suppl., 97, 122; *Marketing of Fish in India*, 1961, 44, 57; Chacko, *Indian Fmg*, 1944, **5,** 259; Venkataraman & Sreenivasan, *Indian Fmg, N.S.*, 1953-54, **3**(10), 22; IS: 2237-1962].

UTILIZATION AND COMPOSITION

Indian prawns and shrimps are reported to be the finest in the world. They are consumed either in the fresh condition or in the form of preserved products. Only a small quantity of the marine prawn catches is consumed locally, nearly 85 per cent of it being dried and converted into pulp. Dried prawn pulp is prepared by cooking fresh whole prawns in brine and then peeling and drying the material, or drying first and then peeling. It is available in markets in four grades, depending upon the size of the prawns processed. A sizeable proportion, especially of the large and medium-sized prawns, is also frozen. Frozen prawns are sold in different grades according to the parts removed before freezing, and also whether fresh or cooked; they are required to be free from any discolouration and off-odours. Prawn meals, rich in protein and suitable as feed rations, can be prepared from the sun-dried or cooked prawns. The thick and hard shell of lobsters can be utilized for making various fancy articles on a cottage industry basis [George, *Indian Seafoods*, 1963-64, **1**(1), 17; IS: 2237-1962; 2345-1963; Pillai, *Bull. cent. Res. Inst., Univ. Kerala*, 1957, **5C**(3), 66; Negi, *Indian J. vet. Sci.*, 1949, **19,** 147; *Marketing of Fish in India*, 1961, 77].

Prawns and shrimps constitute a cheap and rich source of animal protein. They also contain appreciable quantities of calcium, phosphorus, iron, iodine, riboflavin and nicotinic acid. The typical mineral and vitamin values of prawn muscle are as follows: calcium, 90; phosphorus, 240; iron, 0.8; sodium, 66; potassium, 262; chlorine, 2.3; vitamin A, nil; thiamine, 0.01; riboflavin, 0.10; nicotinic acid, 4.8; and choline, 542 mg./100 g. Analysis of the edible portions of prawns, shrimps and lobsters is given in Table 3. Wide variations are observed in the fat content of different species of prawns as well as among individuals of the same species. Mature prawns contain more of fat and less of minerals than the young and immature ones. The deficiency of fat in prawns is made good by the presence of carbohydrates which occur as glycogen and starchy nutrients. Smaller varieties of prawns contain more glycogen than the bigger ones (Chacko, *Indian Fmg*, 1944, **5,** 259; Chidhambaram & Raman, ibid., 1944, **5,** 454; Iodine Content of Foods, 55; Shaikhmahmud & Magar, *J. sci. industr. Res.*, 1961, **20D,** 157; 1957, **16A,** 44).

Prawn and shrimp proteins possess a high biological and nutritive value and digestibility (Table 4). Essential amino acid make-up of the proteins of fresh prawns (*Penaeus monodon*) and lobsters respectively is (as g./16 g. N): arginine, 7.1, 7.2; histidine, 2.3, 1.2; lysine, 8.1, 17.6; tryptophan, 1.8, 0.2; phenylalanine, 6.2, 2.7; methionine and valine, 11.9, 5.1; threonine, 24.6 (including glutamic acid), 5.3; and leucine and *iso*leucine, 15.5, 15.6 (Appanna & Devadatta, *Curr. Sci.*, 1942, **11,** 333; Chari & Venkataraman, *Indian J. med. Res.*, 1957, **45,** 81; Master & Magar, ibid., 1954, **42,** 509).

Non-protein nitrogen accounts for about 60 per cent of the total water-soluble nitrogen in prawns. The distribution of nitrogen in the fresh muscle of *Penaeus monodon* is (as mg. N/100 g.): total N, 3,415; water-soluble N, 1,231; non-protein N, 756.5; α-amino N, 394.2; volatile base N, 64.4; and

TABLE 3—CHEMICAL COMPOSITION OF EDIBLE PORTIONS OF PRAWNS, SHRIMPS AND LOBSTERS

	Marine prawns		Estuarine prawns (*Palaemon* sp.)[3]	Shrimps (*Acetes* sp.) Bombay coast[1]	Lobster (*Panulirus ornatus* var. *decoratus*) Bombay coast[4]
	Bombay coast[1]	Malabar coast[2]			
Edible portion, %	50.0-70.0*	43.0-52.3	..	80.0**	71.0
Moisture, %	67.5-80.1	76.7-78.9	75.5	79.9	76.3
Protein, %	60.1-70.3†	17.6-20.8	21.5	44.2†	19.6
Fat, %	3.1-5.1†	0.4-0.9	1.7	1.5†	..
Carbohydrates, %	13.1-27.7†	0.3-2.0	0	31.8†	..
Minerals, %	9.1-11.5†	1.2-1.7	1.3	22.5†	1.7
Calcium, mg./100 g.	470.0-535.0†	159.0-286.0	38.0	825.0†	178.0
Phosphorus, mg./100 g.	715.0-930.0†	264.0-348.0	249.0	1,975.0†	40.7
Iron, mg./100 g.	27.6-43.1†	1.8-9.4	..	50.5†	2.9

[1] Shaikhmahmud & Magar, *J. sci. industr. Res.*, 1961, **20D**, 157; [2] Chari, *Indian J. med. Res.*, 1948, **36**, 253; [3] Mitra & Mittra, ibid., 1943, **31**, 41; [4] Setna *et al.*, ibid., 1944, **32**, 171.
* Also contains (on dry basis): glycogen, 213-415, and lactic acid, 130.6-180.5 mg./100 g.
** Also contains (on dry basis): glycogen, 435, and lactic acid, 110.5 mg./100 g.
† On dry basis.

TABLE 4—BIOLOGICAL VALUE AND DIGESTIBILITY CO-EFFICIENT OF PRAWN AND SHRIMP PROTEINS

Species	Level of feeding %	Biological val. %	Dig. co-efficient %
Metapenaeus sp.[1]*	5	71.8	86.4
	10	65.7	85.8
	15	59.6	73.2
Parapeneopsis stylifera[2]	5	97.5	97.4
Acetes sp.[1]	5	75.6	83.7
	10	60.7	86.0
	15	54.5	71.9

[1] Appanna & Devadatta, *Curr. Sci.*, 1942, **11**, 333; [2] Valanju & Sohonie, *Indian J. med. Res.*, 1957, **45**, 125.
* Protein content, 19.6%.

glutamine amide N, 33.8. Free amino acids such as lysine, arginine, glycine, proline, valine and leucine occur in significant amounts in the prawn muscle. They contribute to the characteristic flavour of the meat and are also probably responsible for the poorer keeping quality of prawns as compared to teleosts (Velankar & Govindan, *Proc. Indian Acad. Sci.*, 1958, **47B**, 202; Velankar & Iyer, *J. sci. industr. Res.*, 1961, **20C**, 64).

By-products—Prawn shell manure consists of the head, tail and body shell of prawns, which are separated during the preparation of prawn pulp or semi-dried prawns. It has an appreciable quantity of lime and is suitable as a manure for acid soils. It contains: moisture, 15; nitrogen, 5–6; phosphate, 2–5; lime, 13; and insolubles, 15%. Prawn dust obtained during shelling of the prawns can also be used as manure.

Meals prepared from powdered prawn shells are suitable as feed for promoting quick growth of young fishes and are also used as poultry and cattle feed. A process has been developed for the production of poultry feed comparable in quality to fish scrap meal utilizing waste prawn heads and squilla (a side catch in prawn fishing). Analysis of a sample of meal made from prawn heads (sun-dried), gave the following values (dry basis): protein, 45.5; fat, 5.7; total ash, 23.9; acid-insoluble ash, 2.2; calcium, 4.9; phosphorus, 3.1; and sodium chloride, 4.5%; dig. co-efficient, 54.8%. Preliminary feeding trials with the prawn head meal have shown good growth response with poultry and pigs. The prawn heads can also be used for the preparation of cholesterol. Chitosan (a derivative of chitin) and glucosamine hydrochloride have been prepared from the prawn shell wastes [*Marketing of Fish in India*, 1961, 74, 77; Venkataraman & Chari, *Madras agric. J.*, 1950, **37**, 7; Chacko & Krishnamurthi, *Sci. & Cult.*, 1950–51, **16**, 569; Chidhambaram & Raman, loc. cit.; Visweswariah *et al.*, *Res. & Ind.*, 1966, **11**, 5; *Indian Seafoods*, 1965–66, **3**(1), 21].

MARKETING AND TRADE

India has gained prominence during recent years in the prawn and shrimp market of the world. In trade, the terms prawns and shrimps are indiscriminately used and it is often found that one is inclusive of the other. India stands as the second largest supplier of frozen and canned shrimp in U.S.A., next only to Mexico. The introduction of quick freezing facilities, such as installation of a freezing plant in Cochin in 1951 (freezing capacity, 1.5 tonnes of prawns per day; storing capacity, 51 tonnes), has given a great fillip to the export trade.

Prawns and shrimps constitute the major items of seafood exported from India and account for about 82 per cent of seafood earnings. Indian canned and frozen shrimps have recently gained consumer acceptance in highly sophisticated and quality conscious markets in U.S.A., Europe and the East [Nayar, *Seafood Tr. J.*, 1967, **2**(1), 20].

Export—During recent years there has been a tremendous increase in the export of prawns and shrimps. The major items of export include: (*i*) canned products, (*ii*) chilled or frozen prawns, shrimps and lobster tails, (*iii*) dried prawns and shrimps, and (*iv*) prawn and shrimp powder. The export of prawns, shrimps and lobster tails from India is given product-wise in Table 5. Country-wise break-up of the export of cured prawns and shrimps is given in Tables 6 and 7. Only a few countries import prawn and shrimp powder from India. During 1966-67, 85,836 kg. of prawn powder valued at Rs. 69,004 was exported to Malaysia, U.K., Hongkong and Australia. Items of lesser importance exported to various countries include prawn meals, prawn bits and prawn pickles [*Seafood Tr. J.*, 1967, **2**(5), 34].

Every consignment of canned and frozen prawns and shrimps intended for export is now subjected to quality control and compulsory preshipment inspection and certification by Government authorities (with effect from 15 March 1965) to ensure conformity with the prescribed quality standards of the Indian Standards Institution (IS: 2236-1962; 2237–1962; 2345–1963). The inspection is undertaken by the Central Institute of Fisheries Technology, Ernakulam (Kerala).

Since the price of frozen prawns and shrimps, both in the shell-on and in the peeled and deveined forms, is based on colour and size, more attention is now paid to sorting and grading by colour while packing. Great care is now taken in the selection of packaging materials, packing techniques and attractive presentation (Nayar, loc. cit.).

Apart from the steps already taken to step up production, and diversify products and markets, the Marine Products Export Promotion Council, set up

TABLE 5—EXPORT OF PRAWNS, SHRIMPS AND LOBSTER TAILS

(Qty in tonnes and Val. in thousand Rs.)

	1964-65		1965-66		1966-67*	
	Qty	Val.	Qty	Val.	Qty	Val.
Prawns & Shrimps Canned	945	6,624	1,118	9,517	1,713	25,039
Chilled or frozen	6,298	35,217	7,260	43,981	8,209	100,630
Dried, excluding powdered	2,617	7,805	1,156	4,014	1,041	6,007
Powdered	298	216	99	63	86	69
Preparations in air-tight containers	2	16	6	28	5	52
Other than in air-tight containers	..	..	24	89	..	..
Lobster tails Fresh-chilled or frozen	61	581	108	1,246	112	2,142
TOTAL	10,221	50,459	9,771	58,938	11,166	133,939

* June-March.

TABLE 6—EXPORT OF CANNED AND CHILLED OR FROZEN PRAWNS AND SHRIMPS

(Qty in tonnes and Val. in thousand Rs.)

	CANNED						CHILLED OR FROZEN					
	1964-65		1965-66		1966-67*		1964-65		1965-66		1966-67*	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
U.S.A.	548	3,613	387	3,075	652	9,324	4,727	25,198	5,660	34,306	6,617	77,860
U.K.	83	653	238	1,856	536	7,154	3	27	9	49	49	526
Ceylon	58	107	..	..	..	..	(a)	(b)	218	432	4	10
Denmark	52	447	29	276	9	172	..	..	1	6	(a)	7
France	48	452	292	2,890	313	5,030	3	16	5	42	83	898
West Germany	34	370	8	81	22	307	..	..	..	..	(a)	(b)
East Germany	2	21	18	93	30	606	..	..	..	..	..	..
Japan	..	..	..	..	..	..	1,017	6,851	732	4,715	995	14,572
Australia	6	48	3	33	34	466	502	2,887	592	4,209	424	6,294
Italy	13	112	25	165	19	332	(a)	(b)	1	3	..	..
Sweden	14	146	52	407	30	496	..	..	1	3	..	..
Puerto Rico	10	100	11	113	6	106	..	..	..	..	..	..
Belgium	4	35	3	26	16	273	..	..	2	15	10	142
Netherlands	3	41	11	117	22	385	3	23	15	106	12	147
Others	70	479	41	385	24	388	43	215	24	95	15	174
TOTAL	945	6,624	1,118	9,517	1,713	25,039	6,298	35,217	7,260	43,981	8,209	100,630

* June-March.
(a) Less than one tonne. (b) Less than one thousand Rs.

TABLE 7—EXPORT OF DRIED PRAWNS AND SHRIMPS

(Qty in tonnes and Val. in thousand Rs.)

	1964-65		1965-66		1966-67*	
	Qty	Val.	Qty	Val.	Qty	Val.
Ceylon	581	1,167	120	231	24	81
Hongkong	319	1,168	268	974	667	3,495
Singapore	171	463			59	310
U.S.A.	135	548	55	326	42	467
Malaysia	65	233	32	106	52	285
Mauritius	41	168	48	181		313
U.K.	32	134	36	141	35	263
Kuwait	19	44	6	14	12	71
Saudi Arabia	16	39	27	68	11	51
Jamaica	16	93	21	109	22	182
Netherlands	10	59	19	82	12	89
Others	1,212	3,689	524	1,782	50	400
TOTAL	2,617	7,805	1,156	4,014	1,041	6,007

* June-March.

towards the end of 1961, is also actively collaborating with international agencies working for augmenting the consumption of shrimp and shrimp products throughout the world, through promotional programmes [Nayar, loc. cit.; Modawal, *Seafood Tr. J.*, 1967, **2**(1), 55].

Import—The import of frozen and canned prawns and shrimps in India is insignificant compared to the volume exported. The quantity of frozen and canned prawns and shrimps imported during 1964–65 and 1965–66 amounted to 761,872 kg. valued at Rs. 981,943 and 52,609 kg. valued at Rs. 86,196 respectively.

Prices—Reliable price records for prawns are not available for the important markets in the country. The average wholesale price of freshwater prawns in Madras for the year 1966–67 was reported to be Rs. 330 per quintal (*Agric. Situat. India*, 1966–67, **21**; 1967–68, **22**).

PREMNA Linn. (*Verbenaceae*)

A large genus of trees, shrubs or rarely herbs and climbers distributed throughout the warmer parts of the Old World. About 35 species occur in India.

P. bengalensis C.B. Clarke

Fl. Br. Ind., IV, 577 ; Fl. Assam, III, 474.

BENG.—*Dauli.*

ASSAM—*Gohora ;* KHASI—*Dieng-lih ;* GARO—*Bolgoppo ;* CACHAR—*Dhola-uja ;* NEPAL—*Guyheli ;* LEPCHA—*Sungna.*

A small or medium-sized evergreen tree, distributed in the plains and lower hill forests of West Bengal, Bihar and Assam, and in Sikkim Terai area. Bark greyish white, exfoliating in thin papery flakes ; leaves ovate or elliptic ; flowers yellowish, greenish white or white, in corymbs ; drupes globose.

The bark is soft and sweet and edible. The wood (wt., 752–801 kg./cu.m.) is brownish white or cream coloured, hard, even-grained and durable. Old wood is reported to last well in water and has been used for bridges and for house-posts. It is also suitable for turnery and carving (Bor, 302 ; Gamble, 536 ; Troup, II, 778).

P. herbacea Roxb. syn. *Pygmaeopremna herbacea* Moldenke

D.E.P., VI(1), 336 ; Fl. Br. Ind., IV, 581 ; Kirt. & Basu, Pl. 738A.

HINDI—*Bharangi ;* BENG.—*Bhui jam, baman hati ;* MAR.—*Bharangamula ;* TEL.—*Neala neareadu, adavinelli koora, gandu bharangi ;* TAM.—*Buma samba, siru tekku ;* KAN.—*Nai thega.*

ASSAM—*Matia jam ;* GARO—*Mati-pharuwa, bolsal-thanuri ;* MUNDARI—*Hora chalu, ote atil ba ;* SANTAL—*Phin jamun, kada-met.*

A small herb or sometimes an undershrub, arising from a perennial rootstock, commonly met with throughout the sub-tropical Himalayas from Kumaun eastward to Bhutan, and in Assam, extending southwards through West Bengal, Bihar and Orissa into the Deccan Peninsula. Leaves in a rosette, closely appressed to the ground or in 2 or 3 pairs ; flowers greenish yellow, in small corymbs ; drupes globose, black.

This slightly variable species is widely distributed and is remarkable for its peculiar dwarf habit, which is resultant of exposure to periodical fires. Its extensively developed roots are used medicinally. They are usually confused with those of *Clerodendrum serratum,* which are also sold under the same vernacular name *Bharangi.* Fresh rootstocks and roots along with ginger are given in asthma, rheumatism and dropsy. The rootstocks are used to cure toothache. They are reported to contain an acid resin and traces of an alkaloid. The leaves are prescribed in fevers, cough, and rheumatism and their poultices are applied to boils. The ripe fruit is reported to be eaten (Merrill, *J. Arnold Arbor.,* 1951, **32,** 73 ; Dymock, Warden & Hooper, III, 68 ; Nadkarni, I, 1009 ; Bressers, 116 ; Fl. Assam, III, 478).

P. latifolia Roxb.

D.E.P., VI(1), 337 ; Fl. Br. Ind., IV, 577 ; Kirt. & Basu, Pl. 737B.

TEL.—*Pedda-nelli koora ;* TAM.—*Pachumullai, erumai munnai ;* MAL.—*Knappa ;* ORIYA—*Gondhona.*

SANTAL—*Dandra sea.*

A small bushy tree or a shrub met with near the coast in the deciduous forests of the Deccan Peninsula ; it also occurs in southern Bihar, Orissa, and West Bengal. The tree is sometimes grown for its edible leaves. Bark ash-coloured, smooth ; leaves cordate or oval, downy, odorous when crushed ; flowers small, dirty yellow, in compound corymbs ; drupes wrinkled, 4-celled.

This species is very variable and includes four varieties ; of these var. *mucronata* has been raised to the rank of a distinct species. The leaves and tender shoots are eaten in curries, and are also used as fodder. The leaves are reported to be diuretic and are given internally and applied externally in dropsy (Kirt. & Basu, III, 1930).

P. mucronata Roxb. syn. *P. latifolia* var. *mucronata* C. B. Clarke

D.E.P., VI(1), 338 ; Fl. Br. Ind., IV, 578.

HINDI—*Bakar, basota, agnium, tumari, jhatela ;* BENG.—*Gohara.*

PUNJAB—*Ganhila, gian, bankar ;* ASSAM—*Gunarh, gonderi ;* NEPAL—*Gineri.*

A deciduous tree, about 11 m. in height and 1.8–2.4 m. in girth, with short spines on the shoots, distributed throughout the sub-Himalayan tract, ascending to an altitude of *c.* 1,500 m. ; it extends into the plains of Bihar and Assam. Bark pale, often silvery brown, with dark grey or blackish parts, exfoliating in small scales ; leaves aromatic when crushed, ovate, cuneate, glabrous above and pubescent below, especially on the nerves ; flowers greenish white, in terminal corymbose panicles ; fruit globose, purple to black, larger and more verrucose than that of *P. latifolia.*

The bark is reported to be eaten during times of scarcity. In Kumaun, latex from the bark is applied to boils. It is also given to cattle for the treatment of colic (Fl. Assam, III, 476).

The wood is whitish or light purple, hard, heavy (wt., 560–689 kg./cu.m.) and close-grained. Combs are made out of this wood. It is also used as fuel (Cowan & Cowan, 101 : Gamble, 537 ; Trotter, 1944, 228 ; Gupta, 372).

P. obtusifolia R. Br. syn. *P. corymbosa* auct. non Rottl. & Willd. ; *P. integrifolia* Linn. : *Cornutia corymbosa* Burm. f.

D.E.P., VI(1), 337 ; Fl. Br. Ind., IV, 573 in part, 574 ; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 2, 1953, 32, Fig.

SANS.—*Agnimanthah* ; HINDI—*Agetha, arani, ustabunda* ; BENG.—*Bhut-bhiravi, ganiari* ; MAR.—*Chamari, khara-narvel, aran* ; GUJ.—*Mothi-arni* ; TEL. *Pomanti, pedda narva, gaebbu nelli* ; TAM.—*Munnay, muney kiray* ; KAN.—*Eegigida, agnimanda, takkile, bachanige mara* ; MAL.—*Munna* ; ORIYA—*Aguyabat, bhuto bairi.*

ASSAM—*Genderi, ganioli* ; KHASI—*Dieng-lah-marwai* ; NEPAL - *Gineri.*

A large, thorny, deciduous shrub or a tree, up to 9 m. in height, common along the Indian and the Andaman coasts ; it also occurs in the plains of Assam and in Khasi hills. Roots light brown or yellowish brown, woody, aromatic ; leaves elliptic-ovate, sometimes pubescent ; flowers greenish yellow or greenish white, with a strong disagreeable odour, in terminal corymbose cymes ; drupes globose.

Considerable confusion exists regarding the correct botanical nomenclature of this well-known plant. It has been recently shown that according to rules, the earliest valid name to be adopted under the genus *Premna* is *P. obtusifolia*, although an earlier Linnean name, *P. integrifolia*, has been mentioned as a synonym. In fact this species is so variable in habit and shape of the leaves and calyx that it is still undecided whether it is not a complex of several species (Fosberg, *Taxon*, 1953, **2,** 88 ; Corner, I, 705).

The roots form a constituent of the well-known Ayurvedic medicine, *Dasamula*, used as a cure for obstinate fevers. They are prescribed as a laxative, stomachic, cordial and tonic. Commercial drug consists of cylindrical, solid pieces of roots, 6-8 cm. long and 4–5 mm. in diam., brown from outside and yellow from within, having a short fracture. The root bark has a characteristic agreeable odour. The fresh bark is at first sweetish but bitter and astringent later. The supplies of the drug come mostly from Sundarbans and Travancore. The roots of a few other species, such as *P. coriacea* C.B. Clarke and *P. latifolia* are used as substitutes or adulterants (Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 113).

The chief active principles are the three alkaloids: premnine ($C_{11}H_{15}ON$, m.p. 82°), ganiarine (chloroplatinate, decomp. 239–41°) and ganikarine ($C_{19}H_{17}ON$, m.p. 230–32° decomp.). Experiments conducted on frogs showed that premnine and ganiarine caused constriction of the blood vessels and raised the blood pressure, whereas ganikarine had no such sympathomimetic action. Premnine also causes dilatation of the pupils. The roots contain a yellow colouring matter, tannin, and an essential oil which is used in Ceylon for the treatment of colic. Recently, an antibiotic of phenolic nature (m.p. 155–58°) has been isolated from the fresh root bark. It was found to be active against the Gram-positive organisms, such as *Micrococcus pyogenes* var. *aureus, Bacillus subtilis* and *Streptococcus haemolyticus* (Basu & Joneja, *Indian J. Pharm.*, 1949, **11,** 191 ; Chopra *et al.*, ibid., 1956, **18,** 374 ; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 1292 ; Wehmer, II, 1023 ; Lewis, 305 ; Kurup & Kurup, *Naturwissenschaften*, 1964, **51,** 484).

The leaves have an unpleasant odour but are eaten cooked ; they are also used as a cattle feed. They are said to possess carminative and galactagogue properties, and are used in the preparation of a soup given as a stomachic. A decoction of the leaves is reported to be used in the treatment of colic and flatulence, and that of the tender plants for rheumatism and neuralgia. Aqueous extracts of the plant showed a powerful action on the uterus and gut of the experimental animals, causing a marked increase in their activity (Burkill, II, 1807 ; Rama Rao, 315 ; Misra *et al., Labdev J. Sci. & Technol.*, 1966, **4,** 277).

The wood is whitish with purple streaks, or light creamy brown to pale greyish white, pleasantly scented, moderately hard (wt., 560–800 kg./cu.m.), close-grained, and easy to polish. It is used for paddles, knife handles, small cabinets, and turning and fretwork (Gamble, 535 ; Haines, IV, 716 ; Burkill, II, 1807 ; Lewis, 305).

P. tomentosa Willd. BASTARD TEAK

D.E.P., VI(1), 338 : Fl. Br. Ind., IV, 576.

MAR. *Chambara* ; TEL.—*Kampu gummadi, nagaru, naravu* ; TAM.—*Kolakottathekku, pinari, podanganari* ; KAN.—*Ije, iti, naruvalu, narave* ; MAL.—*Katutekka* ; ORIYA—*Kotusumonthi, moria, jhandakai.*

SANTAL.—*Kotokoi.*

FIG. 88—PREMNA TOMENTOSA—FLOWERING BRANCH

A moderate-sized, deciduous tree, up to 18 m. in height, commonly met with in the Deccan Peninsula, ascending up to an altitude of *c.* 1,200 m.; it has also been recorded from Bihar and Orissa. Bark greyish brown or yellowish; leaves ovate, densely coated with tomentum, aromatic; flowers greenish yellow, in panicled corymbs; drupes ovoid, 1–4 seeded.

The leaves are considered to possess diuretic properties and are used in dropsical affections. Their decoction is given after child-birth. The pounded leaves are said to possess vulnerary properties (Lewis, 305; Dymock, Warden & Hooper, III, 70; Burkill, II, 1807–08).

On steam distillation, the leaves yielded a light yellow essential oil (av., 0.07%) with a pleasing odour and burning taste. The oil showed the following characteristics: $d_{1}^{31.6}$, 0.8740; n_{D}^{29}, 1.4862; $[\alpha]_{D}^{28}$, +31.44°; acid val., 0; ester val., 8.9; and acet. val., 14.9. It contained: *d*- and *dl*-limonene, 57.8; *β*-caryophyllene, 17.2; a cadalene-type sesquiterpene, 7.8; a sesquiterpene tertiary alcohol, 5.6; and a diterpene, 5.5% (Laxmi Narayan & Muthana, *J. Indian Inst. Sci.*, 1953, **35**, 55).

An extract of the inner bark is stated to be used to arrest diarrhoea, and a decoction of the roots is given in stomachache. The roots are reported to yield an aromatic oil which is also used in stomach disorders (Burkill, II, 1807–08; Kirt. & Basu, III, 1929).

The wood is light brown or light greyish brown, moderately hard, heavy (wt., 800–961 kg./cu.m.), close- and even-grained, smooth and durable. It seasons without much difficulty and takes polish well. It resembles teak and is used for house building, furniture, combs, weaving shuttles, turnery, carving and fancy work. It is also suitable for rafters and temporary structures. The wood is used as fuel (Gamble, 536; Burkill, II, 1807; Dastur, Useful Plants, 172; Lewis, 306).

P. divaricata Wall. ex Schauer is a sprawling shrub or climber, with ovate or elliptic leaves and white globose drupes, found in the South Andamans. The leaves are eaten; they are also used for the treatment of colds. The fruits are reported to be poisonous (Burkill, II, 1806).

P. longifolia Roxb. (BENG.—*Gohora*; ASSAM—*Gobra-bhodia*; GARO—*Gambolthaprap*; NEPAL—*Guyheli*; LEPCHA—*Sungna*) is an evergreen tree, with ovate leaves, met with in Garo hills of Assam. The wood is greyish brown, hard, heavy (wt., 752–801 kg./cu.m.) and close-grained, and is used for house-posts.

P. milleflora C.B. Clarke (KHASI—*Dieng-phorri*; GARO—*Gambhariskhal*) is a tree, up to 2 m. in girth, with dense corymbs of small flowers, found in Goalpara district, and in the Garo, Khasi, North Cachar and Mikir hills of Assam. The wood is used for house-posts; it possesses unpleasant smell and is said to be resistant against pests (Fl. Assam, III, 475).

P. pyramidata Wall. ex Schauer is a moderate-sized deciduous tree with greyish brown bark, recorded from Sibsagar district of Assam. The wood is hard, heavy (wt., 640–865 kg./cu.m.) and close-grained. It seasons and polishes well, and is suitable for turning and carving, weaving shuttles, bobbins, and toys (Troup, II, 778; Gamble, 536).

Prickly Pear — *see* **Opuntia**

Prickly Poppy — *see* **Argemone**

Primrose — *see* **Primula**

Primrose, Evening — *see* **Oenothera**

PRIMULA Linn. (*Primulaceae*)

A large genus of perennial herbs distributed in the north temperate zone, with the largest number of species found in the Sino-Himalayan region. More than 150 species have been recorded in India.

Commonly known as PRIMROSE, species of *Primula* are of great horticultural interest and are grown for their attractive flowers which may be single or double, and of varied colours—white, pink, rose, red, blue or yellow. Primroses generally thrive from medium to high elevations and can be grown in the plains only in cold season under semi-shady situations. They flourish in rich sandy soils with good moisture, preferably with an acidic reaction. Though perennials, they are treated as annuals under cultivation, and have been found suitable for pot culture. Propagation is done by seeds. In the plains, seeds are sown in September–October, and on the hills in March–May. Propagation by cuttings or division is practised to perpetuate desired varieties (Bailey, 1947, III, 2782–83; Gopalaswamiengar, 456–57; Chittenden, III, 1664; Desai, 146).

Taxonomically the genus has been classified differently by various authorities into several sections or subgenera. Recently even the genus *Androsace* Linn. has been merged with this genus. Genetically, species of the genus are interesting for their heterostyly leading to flower dimorphism [Watt, *J. R. hort. Soc.*, 1904–05, **29**, 295; Balfour, ibid., 1913–14, **39**, 128; Smith & Forrest, ibid., 1929, **54**, 4; Pax & Knuth in Das Pflanzenreich, Heft 22, 1905, 17; Smith & Fletcher, *Trans. bot. Soc. Edinb.*, 1939–40, **33**, 122, 209; 1943–47, **34**, 55, 402; 1949, **35**, 180; Fl. Malesiana, Ser. I, **6**(2), 186].

Species of *Primula* abound in the inner Himalayas; a few are found in the outer southern ranges. They vary greatly in stature, flower and habitat. Most of them are considered poisonous to domestic animals, which do not feed on them while grazing; consequently *Primula* species are abundant in the Himalayan region (Nakao, 10, 47–48).

P. denticulata Sm.

Fl. Br. Ind., III, 485; Bailey, 1947, III, 2800; Coventry, Ser. I, Pl. XXIX.

A perennial herb with stout rootstock found throughout the temperate Himalayas from Kashmir to Bhutan at altitudes of 2,100–4,050 m. and in Khasi and Jaintia hills at 1,500 m. Leaves radical, oblong-spathulate, 5–10 cm. long; flowers lilac, blue, or mauve, borne in clusters on stalks 10–30 cm. long.

Bot. Surv. India. Photo: M. A. Rau

FIG. 89—PRIMULA DENTICULATA—IN FLOWER

This is the commonest and most widespread species in the Himalayas at elevations between 2,100 and 2,700 m., covering often large tracts with its flowers from March to May. It varies greatly in size in different localities. It is one of the hardiest and commonest *Primula* sp. in cultivation and includes numerous varieties and horticultural forms. It is easily raised from seed or by division (Watt, *J. R. hort. Soc.*, 1904–05, **29**, 295; Ludlow, ibid., 1951, **76**, 191; Chittenden, III, 1672).

The flowers of *P. denticulata* are said to be regularly eaten in salads in Bashahr and the powder of the roots held to be of value in killing leeches. The roots are 0.5–3.2 mm. thick and have an acrid taste. Their froth number and haemolytic index, which are 5,000 and 66,000 respectively, indicate that they can be used as a suitable substitute for roots of *Polygala senega*. A new anthocyanidin, hirsutidin (a 7-methylated anthocyanidin) has been isolated from the plant (Watt, loc. cit.; Shah & Sukkawala, *J. sci. industr. Res.*, 1961, **20C**, 57; Harborne, *Nature, Lond.*, 1958, **181**, 26).

P. reticulata Wall.

D.E.P., VI(1), 339; Fl. Br. Ind., III, 483; Kirt. & Basu, Pl. 575A.

KUMAUN—*Bishkopra, jalkutra.*

A perennial, scapigerous herb found in the central and eastern Himalayas in Nepal and Sikkim, at altitudes of 3,300–4,500 m. Leaves long-petioled, oblong-cordate, crenate; flowers yellow, whorled, slightly fragrant.

The plant is considered poisonous to cattle. It is reported to produce dermatitis in some individuals. It is used externally as an anodyne (Muenscher, 187: Kirt. & Basu, II, 1473).

P. rosea Royle

Fl. Br. Ind., III, 485; Coventry, Ser. I, 61, Pl. XXX.

A glabrous herb with elliptic or obovate radical leaves found in the western Himalayas from Kashmir to Kulu and Garhwal, growing in marshes, sides of streams and in ravines near melting snow, at 2,700–4,000 m. Flowers bright or pale rose red, borne in umbels.

This is a very hardy species showing variations due to environmental factors and under cultivation. Glycosides of peonidin and a new anthocyanidin (probably 7-methyl peonidin) named rosinidin have been isolated from the plant (Smith & Fletcher, *Trans. R. Soc. Edinb.*, 1942–43, **61**, 64; Harborne, *Nature, Lond.*, 1958, **181**, 26).

P. sinensis Lindl. CHINESE PRIMROSE

Bailey, 1947, III, 2791, Fig. 3176–79.

A short woody plant, native of China, with very variable habit, reported to be cultivated in gardens in Uttar Pradesh, Nilgiris and Bangalore. Leaves radical, rotundate, lobed; scapes erect, exceeding leaves in length, bearing flowers of varying colours in umbels.

This species includes a large number of cultivated types, with large fringed flowers of blue, white, red, rose, orange-red, scarlet or carmine-purple, borne in clusters. Examination of both the floral and foliar parts of the different genotypes of this species indicates the presence of all the six common anthocyanidins, and also the three flavonols, kaempferol, quercetin and myricetin (Harborne & Sherratt, *Nature, Lond.*, 1958, **181**, 25; Sherratt, ibid., 1958, **181**, 26).

Some species of *Primula* collected from the temperate Himalayas have been reported to be delicately perfumed. Amongst them mention may be made of *P. sikkimensis* Hook. f., *P. stuartii* Wall., *P. elongata* Watt, and *P. listeri* King, the last one having a remarkable smell, reminding the odour of *Geranium robertianum*. One species, *P. obtusifolia* Royle, very common in Sikkim, is reported to have a strong metallic smell, so overpowering that it causes severe headache. The nature of these perfumes is not known (Watt, *J. R. hort. Soc.*, 1904–05, **29**, 295).

A large number of species, other than those already mentioned, are reported to be grown in Indian gardens. Among the important ones are: *P. auricula* Linn., *P. elatior* Hill, *P. japonica* A. Gray, *P. malacoides* Franch., *P. obconica* Hance, *P. veris* Linn. syn. *P. officinalis* Hill, and *P. vulgaris* Huds. syn. *P. acaulis* Hill. Some of these are valued medicinally. The roots of *P. vulgaris* are reported to be a strong and safe emetic. The roots of *P. veris* are considered as a substitute for Senega (*Polygala senega*) roots. Handling of plants of *P. obconica* is said to cause severe dermatitis (Firminger, 466; Vishnu Swarup, 115; Desai, 146; Steinmetz, I, 69; II, 362; Clapham *et al.*, 630; Muenscher, 187).

Some of the above mentioned species are reported to contain saponins of the triterpene type. The roots and rhizomes of *P. veris* and *P. elatior* contain a saponin, yielding the sapogenin primulagenin A ($C_{30}H_{50}O_3$). A flavonol glycoside named primulaflavonoloside (probably a dirhamnoside of kaempferol) has been reported in the flowers of *P. veris*. All the six common anthocyanidins have been detected in the flowers of one or other of the *Primula* species. Flowers of *P. obconica* contain delphinidin 3,5-diglucoside. The leaves of *P. obconica* contain an allergenic substance primin, in the secretion of their glandular hairs, which produces skin irritations in some persons. Primin is highly toxic and produces irritation at concentrations of 0.01–0.02 mg. [Fl. Malesiana, Ser. I, **6**(2), 173; Sherratt, *Nature, Lond.*, 1958, **181**, 26; Harborne, ibid., 1958, **181**, 26; Wehmer, II, 922].

PRINSEPIA Royle (*Rosaceae*)

A small genus of deciduous shrubs distributed in the Himalayas, China, East Pakistan and Formosa. One species occurs in India.

P. utilis Royle

D.E.P., VI(1), 339; Fl. Br. Ind., II, 323; *Curtis's bot. Mag.*, 1952–53, **169**, Pl. 194.

HINDI—*Bekkra, bhekal, cherara, dhatila, jhatela, karanga, krungora, mhat.*

HIMACHAL PRADESH—*Arund, bekkli, garandu, gurinda, kharngura, phulwara, tatua;* GARHWAL—*Bhekor;* JAUNSAR—*Bhekoi, bhek;* KHASI—*Sohmonrit, dieng-sia-soh-khar.*

FIG. 90—PRINSEPIA UTILIS—FLOWERING BRANCH

A thorny shrub, up to 3.5 m. in height, distributed throughout the Himalayas and in Khasi and Jaintia hills of Assam, ascending to an altitude of about 3,000 m.; it has run wild in the Nilgiris since its introduction. Leaves elliptic or lanceolate, up to 12.5 cm. long; flowers yellowish white, in axillary racemes; drupe oblique, ellipsoid, 1.3–1.8 cm. × 1.0 cm., deep-purple to almost black, fleshy; putamen (stone) ellipsoid, smooth, enclosing a single brown seed, having thick oily cotyledons.

The shrub thrives on open sunny situations, and is often grown for hedges; it has a slow rate of growth and is affected by defoliators. The leaves are lopped for fodder, which is not of a high quality [Bor, 65; Gamble, 316; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 58; Laurie, *Indian For. Leafl.*, No. 82, 1945, 15].

The seed kernels yield 37.2 per cent of a semi-drying and pale yellow fatty oil having the following constants: sp. gr.$^{20°}$, 0.9215; $n_D^{20°}$, 1.4625; iod. val. (Hanus), 109.8; sap. val., 200.2; acid val., 23.1; acet. val., 12.3; Hehner val., 89.3; and unsapon. matter, 0.5%. The fatty acid composition of the oil is as follows: myristic, 1.8; palmitic, 15.2; stearic, 4.5; lignoceric, 0.9; oleic, 32.6; and linoleic, 43.6%. Resin acid (1.4%) is also present. Unsaponifiable matter contains sitosterol. Seeds are collected on a small scale during June–July in Himachal Pradesh and the hilly districts of Uttar Pradesh for the extraction of oil, which is used for cooking purpose and as an illuminant. It is reported to be suitable also for hydrogenation and soap making. The oil possesses rubefacient properties and is applied externally in rheumatism and pains resulting from over-fatigue [Puntambekar, *J. Indian chem. Soc.*, 1942, **19**, 183; *Oils & Oilseeds J.*, 1951–52, **4**(12), 19].

The sapwood is white; heartwood reddish, close- and even-grained, compact, very hard and very heavy (wt., 1,105 kg./cu.m.), but is liable to split. It is reported to be used as fuel, and occasionally for making walking sticks (Gamble, 316).

PRIOTROPIS Wight & Arn. (*Leguminosae; Papilionaceae*)

Fl. Br. Ind., II, 65; Fl. Assam, II, 9.

A small genus of shrubs from eastern Himalayas and Socotra. One species, *P. cytisoides* Wight & Arn. (KHASI *Dieng-sia-kurie, dieng-toh-tari*), a somewhat bushy shrub, growing up to 1.8–2.4 m. in height, is found in Khasi and Jaintia hills and along the foot of the hills in Goalpara and Kamrup districts. Leaves 5.0–12.5 cm.: leaflets oblong-elliptic to lanceolate; inflorescence terminal, short-stalked, copious with 10–50 flowers; pods obliquely obovate-oblong, flat. It is usually found in the glades and grasslands and along waterless belts. It is reported to be used as a green manure for paddy in Khasi hills (Hardas & Joshi, *Indian J. Genet.*, 1954, **14**, 47).

PRISMATOMERIS Thw. (*Rubiaceae*)

Fl. Br. Ind., III, 159.

A small genus of trees and shrubs distributed in South-West China, Indo-Malaysian region and tropical Australia. Two species occur in India.

P. tetrandra K. Schum. syn. *P. albidiflora* Thw., Hook. f. (Fl. Br. Ind.) in part, is an evergreen shrub or a tree with elliptic-lanceolate leaves, fragrant, white flowers and dark blue fruits, distributed in Assam, North Bengal, Kerala and the Andamans, ascending up to an altitude of *c.* 1,200 m.

According to some authors *P. malayana* Ridl. dealt with by Burkill, is none other than *P. tetrandra*. The

juice of the leaves is reported to be used in stomach-ache. Fresh wounds are poulticed with the leaves (Corner, I, 553; Fl. Assam, III, 80; Burkill, II, 1808–09).

Pristimera — *see* **Reissantia**

PRIVA Adans. (*Verbenaceae*)

Fl. Br. Ind., IV, 565.

A small genus of perennial herbs distributed in the warm regions of both the hemispheres. One species, *P. cordifolia* (Linn. f.) Druce syn. *P. leptostachya* Juss.; C. B. Clarke, (Fl. Br. Ind.) in part, is found nearly throughout India up to 900 m. on the hills. It is an erect, branched, pubescent herb, 15–90 cm. high, bearing ovate or elliptic, crenate-serrate leaves, white flowers in long racemes and obcordate and echinate pyrenes.

An infusion of the leaves is reported to be used in Africa to cure inflammations of the eye-ball. A paste of the ground seeds is applied to sores (Watt & Breyer-Brandwijk, 1053).

Privet — *see* **Ligustrum**

Privet, Egyptian — *see* **Lawsonia**

Proso — *see* **Panicum**

PROSOPIS Linn. (*Leguminosae; Mimosaceae*)

A genus of shrubs and trees distributed in the arid parts of the tropical and sub-tropical regions of the world. Two species occur wild in India: an exotic species, *P. chilensis,* has become naturalized in many parts of the country.

***P. chilensis** Stuntz syn. *P. juliflora* DC. Mesquite

Raizada & Chatterji, *Indian For.*, 1954, **80,** 675, Pl. I.

Hindi—*Vilayati kikkar, kabuli kikkar, vilayati babul, vilayati khejra.*

A very variable, evergreen spiny or sometimes unarmed tree or shrub, with drooping branches, found either in a wild or cultivated state in the drier parts of India. Bark greyish brown; leaves bipinnate with 2–4 pairs of pinnae: pinnules 10–46 pairs, 5–20 mm. long; flowers small, yellowish in dense spikes; pods yellow, 10–25 cm. x 8–15 mm., straight or falcate, flat or cylindrical, often with transverse depressions between the seeds; seeds 10–30 in a pod, ovoid, flattened, 7 mm. x 3 mm., hard, yellowish brown, shiny.

P. chilensis, usually a small tree, which may attain a height up to 20 m. under favourable conditions, is often reduced to a shrub in very dry situations. Its low branching and bushy form in the early stages, together with its excellent coppicing power, make it a very suitable soil binder and wind breaker. It is also grown for shade and hedges.

This species includes a number of varieties and forms. The two important varieties well known are var. *velutina* Standley and var. *glandulosa* Standley besides the typical one, var. *chilensis*. Var. *velutina* is said to be a more useful timber variety, reaching a height of 16 m. and a diameter of 0.6 m., while var. *glandulosa* is the most popular for afforestation purposes. Var. *glandulosa* has stout axillary thorns, while the typical variety is usually unarmed. Five forms, viz. Argentine, Arid, Mexican, Peruvian and Australian have been introduced into India.

The mesquites are fast-growing, hardy and drought-resistant trees, with remarkable coppicing power. They are suitable for the afforestation of arid and semi-arid lands, and come up well even in saline

FIG. 91—PROSOPIS CHILENSIS VAR. CHILENSIS—FLOWERING AND FRUITING BRANCH

*Some authors consider *P. chilensis* and *P. juliflora* as two distinct species. In most Indian floras, *P. chilensis* var. *glandulosa* has been treated as a distinct species, *P. glandulosa* Torr. (Streets, 638–39).

and rocky areas. Their ability to grow in dry places is attributed to the size and density of their crown, extensive lateral root system, and stout tap-roots, which penetrate the soil to a depth up to 20 m. or even more. Austere requirements of the plants, their rapid growth, comparative immunity to grazing, and low cost of crop production have brought these species into prominence in afforestation. All of them yield good quality firewood; flowers are a source of nectar for bees. Pods provide fodder and are eaten during famine [Standley, 1658; Kaul, *Indian For.*, 1956, **82**, 569; Shah, ibid., 1957, **83**, 472; Harbhajan Singh, *Indian Fmg, N.S.*, 1954–55, **4**(3), 16; Krochmal *et al.*, *Econ. Bot.*, 1954, **8**, 14; Schery, 407, 544].

Mesquite thrives in a dry climate and is a prolific seed bearer. It starts fruiting at the age of 3–4 years, and a 10-year old tree may yield up to 90 kg. of pods annually. The pods have a tough pericarp, consisting of a waxy exocarp, a spongy mesocarp and a cartilaginous endocarp, enclosing the seeds in lomentaceous segments.

As the cartilaginous inner lining of the pod does not allow the seeds to escape easily, natural regeneration through seeds in the normal way is slow, but the seeds that pass out undigested in the droppings of animals sprout readily under favourable environment. Natural regeneration also takes place through root suckers.

Artificial regeneration is effected either by seeds or vegetatively through root and shoot cuttings. For procuring seeds, the pods are collected in May–June or in September–October. They may be broken into one-seeded segments for sowing, or the seeds may be separated by the use of mechanical separators. Treatment of the pods with hot water or acids facilitates separation of the seeds (Kaul, *Indian For.*, 1956, **82**, 569; Harbhajan Singh, loc. cit.; Whyte *et al.*, 316; Murthy, *Andhra agric. J.*, 1954, **1**, 13; Sundararaj *et al.*, *Madras agric. J.*, 1966, **53**, 259).

The seeds collected in May–June may be sown soon after collection, but those collected in September–October should be sown in the beginning of the following April. For line fencing, the seeds may be sown in two adjacent rows about 50 cm. apart with a spacing of about 30 cm. between the sowings. Transplanting of one-year old, nursery-raised seedlings during the rainy season is preferable to direct sowing (Harbhajan Singh, loc. cit.).

Experiments have indicated that root and shoot cuttings with a minimum diameter of 1.25 cm. at the collar and a length of 10 cm. give satisfactory results.

FIG. 92—PROSOPIS CHILENSIS VAR. GLANDULOSA—IN FLOWER AND FRUIT

Pre-rooted stumps, consisting of about 2.5 cm. long stem and about 25.0 cm. long root, obtained from at least one-year old seedlings give better results. The stumps are planted in earthen tubes, 30 cm. × 10 cm., which are placed in sunken beds and watered at intervals. With the first shower of the rainy season, they are planted at the site (Kaul, loc. cit.).

The spongy walls of ripe pods are highly nutritive. They are a fair source of digestible protein and are of importance as a stock feed; the seeds, however, are not digested. In America, pods after removing the seed and coarser parts are used as a staple food. They are ground into a meal and made into cakes, or used for making an alcoholic beverage; seeds are ground into powder for preparing bread. Analysis of the ripe pods gave the following values (dry matter basis): total digestible nutrients, 70.5; digestible protein, 6.9; ether extr., 4.3; carbohydrates, 50.3; crude fibre, 30.8; mineral matter, 4.6; calcium, 0.3; and phosphorus, 0.2%. Feeding trials have shown that dry pods can be utilized as a concentrate to make up for the protein deficiency of such roughages as wheat- and rice-straw. When fed in the dried and crushed state, the pods did not show any deleterious

effect on cattle (Record & Hess, 318; Burkill, II, 1810; Whyte *et al.*, 316; Krochmal *et al.*, *Econ. Bot.*, 1954, **8**, 6: Hedrick, 455; *Indian For.*, 1943, **69**, 483; *Madras agric. J.*, 1955, **42**, 451).

The foliage also can be fed to livestock both in fresh condition and as hay; but in the villages of Gujarat it is reported that fallen dry leaves, if eaten along with grass, have a toxic effect on the animals. Analysis of a sample of air-dried leaves from Bangalore gave: moisture, 7.1; crude protein, 26.3; crude ether extr., 8.5; N-free extr., 31.8; fibre, 24.8; and mineral matter, 1.4%. Carotene content of the green leaves is 4.4 mg./100 g. The leaves are rich in plant nutrients, especially nitrogen, and are, therefore, useful as green manure. They contain: nitrogen, 5.6; phosphorus (P_2O_5), 0.9; potassium (K_2O), 3.11; and calcium (CaO), 1.0%. The leaves contain 0.8 per cent of a dark green wax (m.p. 74.5°). Aqueous and alcoholic extracts of the fresh leaves show a marked antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Bacillus coli*. Aqueous extract of leaves is reported to have toxic effect on tomato seedlings (Paul, *Trop. Agriculturist*, 1953, **109**, 27; Range Gowda & Ramaswamy, *Indian For.*, 1960, **86**, 432: Miller, 146: Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362: Kurtz, *J. Amer. Oil Chem. Soc.*, 1958, **35**, 465; Shankarmurthy & Siddiqui, *J. sci. industr. Res.*, 1948, **7B**, 188; Bennett & Bonner, *Amer. J. Bot.*, 1953, **40**, 29).

The tree exudes a gum, consisting of nearly smooth, light yellowish brown, more or less opaque tears, which are translucent and glassy when fractured. The gum forms a somewhat adhesive mucilage and can be used as an emulsifying agent. It also finds use in confectionery and is sometimes employed for mending pottery (Claus, 1961, 79; Krochmal *et al.*, *Econ. Bot.*, 1954, **8**, 14, 17).

The mesquite gum is used as an adulterant and substitute for gum arabic. It is inferior to gum arabic, from which it differs in not precipitating from aqueous solutions when ferric chloride, lead subacetate or sodium borate solution is added. It readily undergoes hydrolysis when treated with dilute sulphuric acid, yielding L-arabinose and D-galactose (both in crystalline form), and 4-*o*-methyl-D-glucuronic acid in the molar ratio of 4:2:1. Owing to the high content of arabinose, which is easily separable, the gum has proved to be an excellent source of this sugar (U.S.D., 1955, 2; Smith & Montgomery, 20, 284–85; Whistler & Smart, 315; Mantell, 72).

Mesquite wood has limited utility as the timber is available only in small sizes. The wood is dark brown in colour, often with a purplish hue, somewhat odorous, irregularly-grained, coarse-textured, very hard, strong, heavy (wt., 768–929 kg./cu.m.) and durable. It is easy to work, finishes to a smooth surface and takes a fine polish. The timber is used for fence posts. In tropical America, the timber is employed for house building, railway cross-ties, furniture and turnery. A process for the manufacture of hardboard sheets, from the mesquite fibres, without a binder, has been patented in U.S.A. (Record & Hess, 318; *For. Abstr.*, 1954, **15**, 348; *Chem. Abstr.*, 1959, **53**, 19390).

Tannin is present in the dry wood (0.9%), bark (3.0–8.4%), and roots (6–7%) (*Chem. Abstr.*, 1957, **51**, 9803: Range Gowda & Ramaswamy, loc. cit.; Wehmer, I, 493).

P. cineraria Druce syn. **P. spicigera* Linn.; †*Mimosa cineraria* Linn.

D.E.P., VI(1), 340: Fl. Br. Ind., II, 288; Talbot, I, Fig. 267, 268.

Hindi—*Jand, chaunkra, khar, khejra*; Beng.—*Shami*; Mar.—*Shemri, saunder*; Guj.—*Sami, semru, khijado, hamra, kandi*; Tel.—*Jammi chettu*; Tam.—*Perumbay, jambu*; Kan.—*Banni, perumbai*; Mal.—*Parampu, tambu*; Oriya—*Shami*.

A small to moderate-sized tree, evergreen or nearly so, with light foliage and rather slender branches armed with conical spines, found in the dry and arid regions of India. It does not ordinarily exceed a height of 12 m. and a girth of 1.2 m., the maximum recorded being 18 m. and 5.4 m., respectively. Bark grey, rough, exfoliating in thin flakes; leaves bipinnate, usually with 2 pairs of pinnae: pinnules 7–12 pairs; flowers small, yellowish, in slender spikes; pods 10–25 cm. × 5–10 mm., cylindric, torulose or flattish with coriaceous exocarp; seeds 10–15 in a pod, oblong, compressed, with moderately hard, brown testa.

The tree prefers a dry climate and the most important areas of its distribution are characterized by extremes in temperature. In Punjab, *P. cineraria* occurs throughout the alluvial plains and within this region the tree occurs most plentifully in the drier areas where the normal rainfall is 10–25 cm. In peninsular India, where the normal rainfall is found to vary from 50 to 90 cm., the tree is gregarious but is scattered in open dry forests; in some localities,

* Mantissa Plantarum, I, 1767, 68; † Described as *Mimosa cinerea* in Species Plantarum, 1753, I, 517, but corrected to *Mimosa cineraria* in a later edition.

it occurs on black cotton soil in association with other trees.

The tree is a light demander. The young seedlings are sensitive to frost; older plants are drought-resistant. Natural regeneration through seed is confined to moist places, but in the dry situations the tree regenerates itself by root suckers. The seeds retain their viability for at least a year and their dispersal takes place by water, or through birds and animals which eat the sweetish pulp and avoid the seeds.

Artificial regeneration through direct sowings on lands, either subject to occasional floods or under irrigation, has been found to be quite successful. An initial spacing of about 2 m. is generally adopted which may be increased to 6 m. in the coupe. The trees can also be successfully raised by sowings in conjunction with field crops on irrigated land. Growth of the seedlings for the first few years is slow, but subsequent growth up to an age of 40–60 years is moderate; the tree attains an average girth of about 80 cm. in 30 years. In dry areas, where reproduction through seeds is not practicable, regeneration is effected by coppice shoots. The young trees coppice well, but the rate of growth of coppice shoots deteriorates as the trees grow older. Several insect pests affecting seeds, twigs, timber and roots have been recorded; among others, species of *Sinoxylon* and *Chrysobothris* bore into the dead wood and cause wood rot [Troup, II, 389–99; Wadhwani, *Indian For.*, 1953, **79**, 432; Mohan, ibid., 1958, **84**, 127; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 59].

The sapwood is large and white; heartwood scanty, brown to purplish brown, straight to slightly interlocked-grained, medium coarse-textured, strong, tough, very hard and heavy (wt., 769–945 kg./cu.m.). The wood seasons well with care; 2.5 cm. thick planks take 16–20 days to kiln-season and require to be steamed at least twice, during the course of drying, in addition to the initial and final steamings at 55°/100 per cent R.H. for 2–4 hours. The wood is not durable and is liable to insect attack. It turns well and, considering its hardness, is not difficult to saw and work, finishing to a smooth surface and taking paint and polish well. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 110; strength as a beam, 100; stiffness as a beam, 85; suitability as a post, 80; shock-resisting ability, 165; retention of shape, 60; shear, 175; and hardness, 130.

The wood is suitable for interior construction work, such as columns, roofs, doors and windows and for wheels and hubs of carts, agricultural implements, tool handles, small turnery articles and well-curbs. In dry and arid regions, it is a source of fuel (calorific val.: sapwood—5,003 cal., 9,007 B.t.u.), and is used for making charcoal. The wood ash which contains 31 per cent of soluble potassium salts, may be used as a source of potash [Chowdhury & Ghosh, *Indian For. Rec., N.S., Util.*, 1946, **4**(3), 17; Rawat & Rawat, *Indian For. Rec., N.S., Timb. Mech.*, 1960, **1**, 187; Gamble, 288; Rehman, *Indian For.*, 1956, **82**, 252; Sekhar, ibid., 1955, **81**, 724; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 58, Sheet No. 17; Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 14–15, 20; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 20].

The pods are used as fodder for livestock. Before they are ripe, they are rich in a sweetish farinaceous pulp, which is consumed as food, especially in times of scarcity. The pods are eaten green, dried or after boiling and are considered to possess astringent, demulcent and pectoral properties (Harbhajan Singh, *Indian J. agric. Sci.*, 1945, **15**, 300).

The bark has a sweetish taste. It is reported that during the severe famine of Rajputana in 1868–69, many lives were saved by the use of bark as a source of food; it was ground into flour and made into cakes. The bark as well as the galls, formed on the leaves, are used for tanning. The leaves are much lopped for fodder. They are also useful for green manuring. They contain: N, 2.9; phosphorus (P_2O_5), 0.4; potassium (K_2O), 1.4; and calcium (CaO), 2.8%. The flowers are mixed with sugar and administered to prevent miscarriage. Patulitrin, a flavone glycoside (m.p. 252–53°), has been isolated from the flowers (Trotter, 1940, 277; Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362; Kirt. & Basu, II, 911; Sharma *et al.*, *Indian J. Chem.*, 1964, **2**, 83).

The tree exudes a gum, which resembles the mesquite gum, from the cut ends of branches. The gum occurs in small, angular, friable, yellow fragments, or sometimes in large ovoid tears, about 5 cm. long. The tears have frosted appearance and are internally amber-coloured, cracking to pressure because of the presence of numerous minute cracks. They form with water a dark coloured tasteless mucilage of about the same viscosity as that of gum arabic (Dymock, Warden & Hooper, I, 550).

P. stephaniana Kunth is a spiny shrub or a small bushy tree, found in parts of Punjab and Gujarat.

The thick pods are brown in colour and usually become swollen and contorted due to gall formation. They are used in Afghanistan and Iran for tanning and as fodder. The pods and roots are stated to possess astringent properties and are used in dysentery. It has been reported that the pods may yield a substitute for wood-shavings used in various industries for thermal insulation and acoustic control. The seeds yield 2–3 per cent of a fatty oil (Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 99; Narayanamurti, *Indian For. Bull., N.S.*, No. 207, 1955, 41; Mensier, 467).

PROSORUS Dalz. (*Euphorbiaceae*)

A small genus of trees distributed in the Indo-Malaysian region. One species occurs in India.

P. indicus Dalz. syn. *Phyllanthus indicus* Muell. Arg.

D.E.P., VI(1), 221; Fl. Br. Ind., V, 305; Worthington, 372.

KAN.—*Hannu nanne, kali-kudai, pan nana.*

ASSAM—*Gunamala, lukora.*

A moderate-sized, deciduous tree, up to 18.0 m. in height and 1.5 m. in girth, occurring along the streams and in swamps in the sub-Himalayan tracts of Kumaun, and in Assam, Orissa and the western ghats from Konkan southwards. Bark greyish white, smooth, papery, exfoliating in large flakes; leaves broadly elliptic or oblong, up to 20 cm. × 7 cm.; flowers dioecious, in fascicles; capsules globose, 6–12 mm. in diam.; seeds purplish blue, arillate.

The wood is reddish white, close- and compact-grained, tough, hard and heavy (wt., 865 kg./cu.m.). It shows well-pronounced, wavy, medullary rays in the radial section and can be worked to a smooth finish. It is used for building purposes and is suitable for minor decorative work and turnery (Talbot, II, 443; Howard, 454).

The leaves are reported to contain an amorphous alkaloid (Heyne, I, 905).

PROTIUM Burm. f. (*Burseraceae*)

A genus of trees, occasionally shrubs, distributed in tropical America and from Malagasy to Indo-Malaysian region. One species occurs in India.

P. serratum Engl. syn. *Bursera serrata* Wall. ex Colebr.
INDIAN RED PEAR

D.E.P., I, 548; Fl. Br. Ind., I, 530; Bor. Pl. XXIII(1).

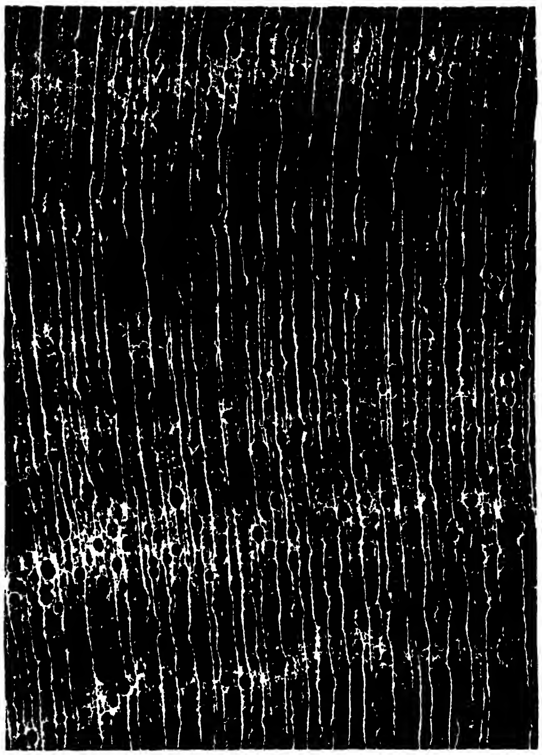
BENG.—*Gutgotya*; TEL.—*Chitreka*; ORIYA—*Nimburu, nimburamoi, sorupotri moi.*

ASSAM—*Mirtenga*; KHASI—*Dieng-soh-mir*; LUSHAI—*Bil*; GARO—*Thikring*; MUNDARI—*Kandeor daru.*

TRADE—*Murtenga.*

An evergreen tree, up to 15 m. in height and 1.8 m. in girth, with 5–6 m. long (up to 12 m. in Burma), straight, cylindrical bole, found in Assam, Bihar, Orissa and Andhra Pradesh. Bark grey or brownish, fibrous; leaves imparipinnate; leaflets 7.5–14.0 cm. long, ovate to oblong, sometimes elliptic-lanceolate, more or less serrate; flowers small, greenish, in panicles; drupes globose, 1.3–2.0 cm. in diam., red.

The tree occurs commonly along the streams, in ravines, or on rocky ground in cool situations, and is occasionally planted in gardens. Natural seedlings spring up in moist places and young trees withstand moderate shade. The tree coppices well and is a good alternative host for *Kusumi* strain of the lac insect, especially for growing *Aghani* crop. The fruits are pleasantly acidic and are edible [Troup, I, 174; Parker, 71; Fl. Assam, I, 223; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 60; Purkayastha & Krishnaswami, *Curr. Sci.*, 1961, **30**, 153].



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 93—PROTIUM SERRATUM—TRANSVERSE SECTION OF WOOD (×10)

Sapwood is light brown; heartwood is bright red when first exposed, turning brick red or dull brown with age, narrowly interlocked-grained and frequently wavy-grained in the radial plane, even- and medium-textured, fairly strong, tough and heavy (sp. gr., c. 0.77; wt., 720–801 kg./cu.m.). The wood can be seasoned well with care. Either girdling or green conversion is advocated; in case the latter method is followed, the timber should be converted early in the cold weather and placed in a shed in fairly close piles. It is durable, especially under cover: graveyard tests indicate a life of 5–10 years. The wood is very refractory to treatment, side and end penetration of preservative being practically nil. It is not difficult to saw and can be worked to a smooth shiny surface. If sawn on the quarter, the interlocked fibre presents a handsome appearance, especially after polishing (Pearson & Brown, I, 224; Rodger, 52; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49; IS: 399–1963).

The timber is used for house construction, chiefly for door and window frames and ceiling planks, posts of temporary sheds, solid wheels and shafts of carts, ploughs and furniture. It is reported to be suitable also for decorative work, turnery, carving and cabinet-making, and for plywood. In Burma, it has been used for railway sleepers (Pearson & Brown, I, 226; Howard, 102; Rodger, 52).

Proustite — *see* **Silver Ores**

PRUNUS Linn. (*Rosaceae*)

A large genus of deciduous or evergreen trees and shrubs, distributed chiefly in the temperate regions of the northern hemisphere. Many species are in cultivation for their edible fruits and a few for their edible seeds. A large number of them are valued as ornamentals on account of their showy flowers. About 19 species occur wild in India and a few others have been introduced and grown for their fruits.

The genus includes a large number of stone fruits, viz. apricots, cherries, plums, peaches, as well as the almonds. These are well-marked groups, some of which have been regarded as distinct genera by various authors. However, in all recent treatments the splitting of this genus into several genera is not favoured and the entire genus is dealt with under a smaller or larger number of sub-genera and sections. Recently, the genus *Pygeum* has also been reduced to a sub-generic status under this genus (Rehder, 1949, 318–50; Mansfeld, 135–44; Kalkman, *Blumea*, 1965–66, **13,** 1–115).

P. amygdalus Batsch syn. *P. communis* Fritsch; *Amygdalus communis* Linn. ALMOND

D.E.P., VI(1), 342; C.P., 905; Fl. Br. Ind., II, 313.

HINDI, BENG., MAR., PUNJABI—*Badam;* TAM.—*Vadamkottai;* TEL.—*Badam vittulu;* KAN.—*Badami;* MAL.—*Vatam-kotta.*

A tree, up to 8 m. high, with oblong-lanceolate minutely serrate leaves; flowers solitary, pink or nearly white, 2–5 cm. across, showy and appearing before or with the early foliage; fruit a drupe, about 3–6 cm. long, pubescent, with tough flesh splitting at maturity, exposing the pitted stones: endocarp thin or thick; seed flattened, long, oval, with a brownish seed coat.

This species includes three varieties, viz. var. *amygdalus*, var. *amara* (DC.) Focke and var. *sativa* (Ludw.) Focke. The first one includes wild types found in West Asia, Greece, and North Africa: the second and the third include a large number of cultivated types, var. *amara* comprising mostly the BITTER ALMOND and var. *sativa* the SWEET ALMOND. The almond is said to be originally a native of central and western Asia, where it is reported to be found wild even at present. It is said to have been cultivated in China as early as the 10th century B.C. and in Greece in the 5th century B.C. At present it is cultivated throughout southern Europe, in U.S.A. (California), Australia and South Africa. In India, the almond is cultivated in Kashmir at elevations of 760–2,400 m. and is said to be one of the principal crops in this region. The present area under this crop is estimated at 2,400 hectares with a production of 5,600 quintals. A smaller area of about 200 hectares is under this crop in Himachal Pradesh. There are excellent possibilities of growing this crop in the cool and dry areas of the latter State, especially in the Chini area and to a lesser extent in Lahul: trial cultivation is reported to have given good results. The almond is said to have been extensively planted in some of the hilly areas of Uttar Pradesh also, but the fruiting has not been very encouraging due to heavy rainfall which is characteristic of these areas. It is estimated that about 5,000 hectares are devoted to almond and walnut in Uttar Pradesh but separate figures are not available [Mansfeld, 139; Howes, 1948, 105, 110–12; Hill, 356; Sham Singh *et al.*, 354; Singh, *Gardening*, 1956–59, **1**(5), 26; Information from the Directorate of Fruit Utilization, Uttar Pradesh].

Cultivated types of almond suffer from one or more drawbacks such as having a very hard or very

soft shell, gummy kernels, fruits that cannot be easily jarred or knocked off from trees at harvesting, and many other undesirable characters. Desirable characters which are found occurring among some almond types are, late blooming, full bearing, good qualities for harvesting, hulling and shelling, a high degree of resistance to pests and diseases, and general excellence of kernel. The aim of the almond breeder is to combine as many of these good qualities as possible in a few types, eliminating at the same time any drawback that they suffer from (Crane *et al., Yearb. Agric., U.S. Dep. Agric.*, 1937, 865; Wood, *Circ. Calif. agric. Ext. Serv.*, No. 103, 1937, 1–96; Zhukovsky, *Euphytica*, 1965, **14**, 177).

Besides types grown for their fruits, this species includes a large number of ornamental types, some double flowered, white flowered or with variegated leaves; there are also dwarf and weeping types. In some countries, these trees, grown mainly for ornamental purposes, have given fair yield of almonds. Almond flowers are valued for nectar and pollen by beekeepers (Bailey, 1947, III, 2832; Howes, 1948, 197–200).

Both the bitter and sweet almond types are grown as orchard crops, the former being mostly used in the commercial preparation of oil of bitter almonds and also as rootstock for the latter. The sweet almonds are classified into three groups—Hard-shell types, Soft-shell types and Paper-shell (*Khagzi* or *Rumali*) types, depending upon the thickness of the shell. There are no standard types of almond in India; the almond trees cultivated in India are mostly of seedling origin and as such, highly variable. However, some well-known types introduced from U.S.A. are being grown in orchards along with the seedling trees of local origin. The most important introduced types are: *Non Pareil* and *Thin-shell* (Paper-shell types); I.X.L. and *Ne-Plus-Ultra* (Soft-shell types); and *Drake* (Hard-shell type) (Zielinski, 169; Sham Singh *et al.*, 355).

Cultivation

Climate and Soil—The almond requires a cold and dry climate, but a fairly warm weather during its ripening period. A rainfall of about 60 cm. or more is required for good cropping. As it flowers very early in the spring it is successful mainly in areas where there is minimum of spring frosts. The greatest injury to the flowers and the setting fruit is said to occur when frost follows one or more days of warm weather, while a constant low temperature may do no harm. There are, however, late blooming types which have greater chance of escaping such frost. The tree is deep rooted and requires a deep, fertile, well-drained soil. It is said to be comparatively more tolerant of drought but most intolerant of standing water (Sham Singh *et al.*, 355; Mustafa & Janjua, *Indian Fmg*, 1942, **3**, 539; Bailey, 1947, I, 250).

Propagation—The common practice in India is to raise the trees from seedlings. Seeds which are usually collected during July–September are kept in a cool and dry place till the following December before sowing. Some artificial practices are adopted to break the resting period by chilling the nuts at a low temperature for about two months. Seeds are sown in nurseries and seedlings transplanted after one year (Sham Singh *et al.*, 357).

Budding and grafting are also employed to raise plants of chosen types, the rootstocks commonly used being bitter or sweet almond, apricot, peach, plum and myrobalan plum seedlings. Almonds are said, however, to do their best on almond stocks, the bitter almond stock giving, according to some, the better tree. Budding is done when the seedlings are 2–3 months old and are about 20–30 cm. high. Grafting is done by tongue or whip grafting when the stock and scion are of equal thickness, or by crown or bark grafting when stock is thicker than scion (Sham Singh *et al.*, 358; Chandler, 1957, 362; Wood, loc. cit.).

The trees are planted 6–8 m. apart in circular pits 1 m. in diameter. Even in areas having about 60 cm. of rainfall, periodic irrigation during dry summers is said to be helpful. The plant has a rather high nitrogen requirement and when nitrogen is deficient many of the flowers either fail to set fruit or when fruits do set, they yield very small almonds. Application of organic matter and nitrogenous fertilizers is said to give increased yield (Sham Singh *et al.*, 361; Chandler, 1957, 363).

The almond tree tends to grow large, with long branches which may become very heavily loaded with fruit. The tree is preferably pruned to a modified leader system. The fruit is borne largely on short spurs, which remain productive up to five years and pruning of surplus branches may be done to about one-fifth of the old bearing wood in bearing trees (Thapar, 78, 115; Chandler, 1957, 364).

Trees which begin to show a gradual decline in production due to age, disease or improper rootstock may temporarily be rejuvenated by being severely cut back at the top. A more profitable procedure,

generally, is to interplant the old declining orchard with young trees and to remove the older trees as the younger ones come into bearing (Wood, loc. cit.).

Pollination—As all the types of almond are said to be self-sterile, and some are cross-incompatible also, it will be beneficial to plant compatible types in the orchard. This problem will not, of course, arise when only seedling trees are grown or when budded or grafted plants are grown along with the seedling plants. A good arrangement is to plant three rows of main type and one row of the pollinating type. The types to be planted in an orchard should also be studied with regard to their period of blooming so that they blossom together for effective pollination. Keeping hives of the honey-bee in the orchard during the blooming period is recommended, as the pollinating activity of wild bees alone may not be sufficient [Wood, loc. cit.; Sham Singh *et al.*, 359; Chandler, 1957, 360; Muttoo, *Indian J. Hort.*, 1950, **7**, (3–4), 17; Mukherjee & Shah, *Himachal Hort.*, 1961–62, **2&3**, 149].

Diseases and Pests—Shot hole caused by *Clasterosporium carpophilum* (Lev.) Aderh., white spongy rot caused by *Fomes lividus* Kl., brown patchy rot of leaf caused by *Phyllosticta prunicola* (Spiz) Sacc., brown rust caused by *Sphaerotheca pannosa* (Wallr.) Lev., and a mosaic disease caused by a virus are reported to occur on the almond in India (*Indian J. agric. Sci.*, 1950, **20**, 107; Bisht & Gupta, *Sci. & Cult.*, 1962, **28**, 178).

The chrysomelid, *Mimastra cyanura* Hope, and the almond weevil, *Myllocerus laetivirens* Marshall, which feed on the leaves are two of the more important pests of the almond in this country. Spraying with a suitable stomach poison during the premonsoon period is said to prove helpful. The San Jose scale, *Quadraspidiotus perniciosus* Comstock, is reported to be a minor pest on almond. It attacks the almond in its early stages when it can be controlled by spraying with miscible dormant oils or with diesel oil emulsion. Biological control of this pest with the aid of selected predators and parasites is being tried successfully in Himachal Pradesh. Their mode of infection and control are similar to that described under apple (*Malus*) (q.v.). The almond moth, *Ephestia cautella* Wlk, infests shelled almonds as well as a number of other dried fruits like apricot, peach, plum, currants, dates and figs [Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 1, 2, 11; Sham Singh *et al.*, 362; Chatrath, *Himachal Hort.*, 1961–62, **2&3**, 53; Jolly, ibid., 1961–62, **2&3**, 163; Sharma & Bhalla, ibid., 1961–62, **2&3**, 235; Sharma & Kumar, ibid., 1965, **6**(2–3), 5; Chhotey Singh, *Indian Hort.*, 1962–63, **7**(3), 6].

Gummosis of fruit and premature fruit drop are said to be caused by a deficiency of copper and boron, and have been reported to affect almond trees in Uttar Pradesh. Application of these elements in the form of sprays one week after fruit set is said to have given favourable results. Non-infectious bud failure or crazy-tip, characterized by failure of leaf buds to grow, is thought to be a genetic disorder that affects certain types of almond, like *Non Parcil* and *Peerless*. The affected branches eventually become unproductive. Top working of the affected trees with scions from trees that do not have the disorder is recommended [Srivastava & Bose, *Fertil. News*, 1964, **9**(8), 27; Wilson, *Calif. Agric.*, 1961, **15**, 5].

Harvesting and Yield—The almond crop comes to harvest from July to September. When the fruits ripen the husk or flesh splits open, exposing the stone. The fruits are harvested at this stage before the stones begin to fall. The harvested fruits are cleaned of the dried skin by hand in this country, while in the larger orchards of California in U.S.A., machinery which works on a rolling and rubbing principle is employed. After being cleaned, almonds are dried in the sun for a short time; over-exposure to sun is avoided as the shell may turn dark and unattractive. They are often bleached by exposing the steamed material to sulphur fumes to give the surface of the shell a bright golden yellow colour. While proper bleaching does not affect the flavour in any way, over-bleaching may cause the kernel to deteriorate and taste soapy, besides giving a duller colour (Sham Singh *et al.*, 361; Wood, loc. cit.; Chandler, 1957, 362; Kirk & Othmer, IX, 560; Howes, 1948, 108–09).

Almond trees are said to bear light crops in three to four years of planting and reach optimum production in eight to ten years. The average yield over a long period in California is reported to be about 400 kg. per hectare, though yields of 1,220 kg. and even more are said to be quite common. In Baluchistan, an average yield of 2,375 kg. per hectare has been reported based on an average yield of about 7.3 kg. per tree and about 325 trees per hectare. In Kashmir, the yield is reported at about 2.7 kg. per tree (Wood, loc. cit.; Sham Singh *et al.*, 361; Mustafa & Janjua, loc. cit.).

Grading—Grading standards for almonds have been developed in U.S.A. Almonds are graded into

several classes to meet the demand for specific purposes. In some types which are sold to the trade mostly in the shell, the main factors of importance for grading are size and appearance, but in others the kernel content, i.e. the percentage of kernel in stone is the important factor. Shelling of the almonds and the subsequent grading of kernels is done in machines in U.S.A. Grading is done on a count-per-ounce basis, starting at 18–20 and running to 70–72 kernels per ounce (Wood, loc. cit.).

Storage—Unshelled almonds will keep for six months or longer in a cool, dry, well-ventilated place. They can also be kept in cold storage, either in the shell or in kernel form, at temperatures around freezing point and at a humidity of 70–75 per cent for well over one or more years (Wood, loc. cit.).

Utilization and Chemical Composition

Almond kernels are often eaten fresh or as dessert; kernels obtained after blanching, roasting, frying and salting are highly esteemed. The kernels are extensively used in confectionery and for the preparation of almond milk. Almond paste made from blanched kernels is used for the production of macaroons, but generally the kernels of apricot, peach and plum are substituted for those of almond. Almond oil extracted from sweet as well as bitter almonds is extensively used in confectionery and also for pharmaceutical and cosmetic preparations. Almond flour made from the residue left after expressing almond oil, and almond butter are free from starch and are used for the preparation of diabetic food, as well as in the manufacture of cosmetics, soaps and detergents. Almond butter which consists of ground roasted kernels to which salt is added can keep for a long time in vacuum-sealed containers. In some countries, almonds in the milky stage picked from fruits still green and immature are eaten as dessert or are candied, preserved and pickled (Howes, 1948, 112; Winton & Winton, I, 476–77, 481; Kuppuswamy *et al.*, 99–100; von Loesecke, 1942, 335; Wood, loc. cit.).

Almond kernels are considered highly nutritious, demulcent and stimulant nervine tonic in indigenous medicine. They are also considered lithontriptic and diuretic, and their poultice is useful for irritable sores and skin eruptions. The kernels are valuable in diets for peptic ulcer. The unripe fruit is given as

FIG. 94—PRUNUS AMYGDALUS—DIFFERENT GRADES OF ALMONDS, UNSHELLED AND SHELLED

an astringent application to the gums and mouth (Chopra *et al.*, I, 361 ; Kirt. & Basu, II, 953 ; *Chem. Abstr.*, 1964, **60**, 2229 ; I.P.C., 15).

The percentage of kernel widely varies with type ranging from 33 in almonds with hard shell to 70 in those with papery shell. The kernels are a rich source of fat and proteins, and have a calorific value of 655 cal./100 g. Analysis of the kernels of Indian sweet almond gave: moisture, 5.2 ; protein, 20.8 ; fat (ether extr.), 58.9 ; carbohydrates, 10.5 ; fibre, 1.7 ; and mineral matter, 2.9% ; calcium, 230 ; oxalic acid, 407 ; phosphorus, 490 ; iron, 4.5 ; thiamine, 0.24 ; nicotinic acid, 2.5 ; and riboflavin, 0.15 mg./100 g. Ascorbic acid and vitamin A are absent. The kernels also contain folic acid (0.45 p.p.m.), α-tocopherol (15 mg./100 g.) and γ-tocopherol (0.5 mg./ 100 g.). The carbohydrates present include sucrose (4.4-4.7%), pentosans and hemicelluloses ; starch is absent. The mineral constituents in the kernels are: sodium, 5.8 ; potassium, 856 ; calcium, 247 ; magnesium, 257 ; iron, 4.23 ; copper, 0.14 ; phosphorus, 442 ; sulphur, 145 ; and chlorine, 1.7 mg./100 g. Iodine (2 μg./100 g.), manganese and zinc are also present. About 82 per cent of phosphorus occurs as phytic acid (Winton & Winton, I, 480, 485 ; Nutritive Value of Indian Foods, 64, 99, 130 ; Sherman, 432 ; Lambertson *et al.*, *J. Sci. Fd Agric.*, 1962, **13**, 617 ; Thorpe, I, 259 ; McCance & Widdowson, 83 ; Iodine Content of Foods, 103 ; Kirk & Othmer, IX, 556).

The chief protein of almond is a globulin, amandin (N content, 19%) ; an albumin is also reported. The essential amino acid make-up of amandin is: arginine, 11.9 ; histidine, 1.6 ; lysine, 0.7 ; phenylalanine, 2.5 ; leucine, 4.5 ; and valine, 0.2%. Tryptophan (1.4%), methionine (0.7%) and cystine (0.8%) are also present. Amandin has a high arginine content. At 9 per cent level of intake, almond protein has a high digestibility co-efficient (94%), but comparatively low biological value (50.8%). It is believed to be a good supplement to milk (Winton & Winton, I, 481–82 ; Kuppuswamy *et al.*, 99, 102).

On an average, the protein content in bitter almond kernel is about 10 per cent higher and the fat content about 10 per cent lower than in sweet almond kernel. The primary chemical difference between the two types, however, lies in the high content (2.5–3.5%) of amygdalin in bitter kernel, the ripe sweet almond being free of this cyanogenetic glucoside. Owing to the presence of amygdalin, which on enzymatic hydrolysis yields hydrocyanic acid, the bitter almond is not fit for human consumption. Amygdalin appears to be an intermediate product in the formation of protein during ripening. In sweet almond, owing to the active metabolism, the glucoside diminishes rapidly as the fruit ripens and disappears in the ripe kernel (Winton & Winton, I, 483–84).

Expressed Almond Oil—A fatty oil, known as Expressed Almond Oil or Sweet Almond Oil, is obtained by cold expression from the kernels of either variety of almond, sweet or bitter. Bitter almond is, however, the chief source of the commercial oil because sweet almond is too valuable to be pressed for oil, and further the press cake from bitter almond is used in the manufacture of an essential oil (Bitter Almond Oil). The oil yield from bitter kernels is usually in the range 38 to 45 per cent and from sweet kernels 44 to 55 per cent. There is little or no difference between the oils from the two types. The expressed almond oil is a clear, pale yellow or colourless liquid, with a mild pleasant odour and a bland taste. It ordinarily requires no refining other than settling and filtration, and has excellent keeping qualities (Eckey, 456-58 ; Thorpe, I, 260 ; Jamieson, 32 ; U.S.D., 1955, 45).

The oil remains clear at −10° and does not congeal until cooled to nearly −20°. Table 1 gives the range of characteristics of the almond oil. The approximate fatty acid composition is as follows: myristic, 1 ; palmitic, 5 ; oleic, 77 ; and linoleic, 17%. The oil has been estimated to consist principally of dioleins and triolein in the proportions of myristo-diolein, 3 ; palmito-diolein, 14 ; linoleo-diolein, 52 ; and triolein, 31. An examination of the oil (iod. val., 95.6) from sweet kernels from Kashmir showed the following fatty acid composition: myristic, 0.2 ; palmitic, 8.9 ; stearic, 4.0 ; oleic, 62.5 ; and linoleic, 24.4% (Eckey, 457–58 ; Hilditch, 1956, 364 ; Subramanyan & Achaya, *J. Sci. Fd Agric.*, 1957, **8**, 657).

The expressed almond oil is seldom used as food because of its high cost. Its principal uses are in the pharmaceutical and cosmetic industries. It is demulcent, nutritive and slightly laxative. It has action similar to olive oil and is used in emollient preparations including nourishing creams, skin creams, and cold creams. It is employed as a vehicle for oil injections. The oil is official in Indian Pharmacopoeia. The commercial product is often adulterated with the fatty oils from peach, apricot, or plum kernels which resemble it to such an extent as to make their detection difficult or uncertain (Eckey, 457 ; B.P.C., 1963, 22 ; U.S.D., 1955, 46 ; I.P., 759).

TABLE 1—PHYSICO-CHEMICAL CHARACTERISTICS OF KERNEL FATS FROM PRUNUS SPP.

	Almond kernel oil		Apricot kernel oil		Cherry kernel oil*	Plum kernel oil		Peach kernel oil
	(1)	(2)†	(1)	(2)†	(1)	(1)	(3)†	(1)
Sp. gr., 25°/25°	0.913–0.916	0.925 (at 20°)	0.912–0.916	0.915 (at 20°)	0.916–0.925	0.911–0.916	0.912 (at 18.5°)	0.913–0.918
$n_D^{40°}$	1.463–1.465	1.472 (at 20°)	1.462–1.465	1.472 (at 20°)	1.466–1.471	1.462–1.465	1.471 (at 18.5°)	1.462–1.464
Acid val.	0.1–3.0	1.5	0.2–4.0	20.1	0.8–5.0	0.5–3.0	1.2	0.4–3.0
Sap. val.	188–197	200	188–200	194	190–198	188–195	192	189–194
Iod. val.	94–105	97	97–109	100	110–118	100–110	91	95–110
R.M. val.	0–0.4	..	0–0.6	..	0.3	0.3	..	..
Polenske val.	0.2–0.8	..	0.1–0.5	..	0.2	0.3	..	0.3–0.5
Unsapon. matter, %	0.4–1.0	1.0	0.4–1.4	1.2	0.4–0.7	0.4–0.9	1.6	0.7

[1] Eckey, 458; [2] Dang *et al.*, *Indian Oilseeds J.*, 1964, **8**, 110; [3] Dhingra & Dhingra, *Indian Soap J.*, 1952-53, **18**, 187.
* *P. cerasus*. † Indian sample.

Bitter Almond Oil—The press cake, left after expression of the fatty oil from bitter kernels, is the source of the essential oil, Bitter Almond Oil (Oleum Amygdalis Amarae). The essential oil does not exist as such in the seeds but in the form of the glucoside amygdalin ($C_{20}H_{27}NO_{11}$, mandelonitrile gentiobioside). For commercial production of the oil, the powdered press cake is macerated with 10 parts of water for about 12 hours at 50–60°. Under the influence of the enzyme emulsin, which is present in the kernels and freed by crushing of the latter, the glucoside gets hydrolysed into benzaldehyde, hydrocyanic acid, and glucose. Upon completion of hydrolysis, the material is steam distilled. To obtain the maximum yield of oil, it is necessary to redistil the distillation water, because benzaldehyde, the chief constituent of oil, is quite soluble in water. The press cake yields on an average 1 per cent of oil corresponding to about 0.5 per cent from the kernel; oil yields up to 0.8 per cent have been obtained from the kernel. The residual powdered material can be pressed into cakes and used as cattle feed (Guenther, V, 49; Thorpe, I, 261; Finnemore, 370).

Bitter almond oil is a colourless, highly refractive liquid, possessing the typical odour of crushed bitter almond. On storage, the oil turns yellow in colour. It should be smelt with caution because of the presence of hydrocyanic acid. The physico-chemical properties of the oil vary within the following limits: sp. gr.$_{25°}^{25°}$, 1.049–1.058; $[\alpha]_D$, inactive to +0.2°; $n^{20°}$, 1.5403–1.5435; benzaldehyde content, 81.3–93.2%; hydrocyanic acid content (including benzaldehyde cyanohydrin), 2.1–4.0%; solubility, 1–2 vol. in 70% alcohol and 5–6 vol. in 50% alcohol. Some samples of oil have been reported to contain as high as 14 per cent hydrocyanic acid (Guenther, V, 50; Chopra *et al.*, I, 361).

Bitter almond oil containing hydrocyanic acid finds limited use in medicine as an antispasmodic and sedative. Dissolved in 50 times water, it is employed externally in prurigo senilis and other cases of troublesome itch. The oil from which hydrocyanic acid has been removed is used for flavouring purposes. Such a product is prepared by heating the oil with a mixture of calcium hydroxide and ferrous sulphate, when hydrocyanic acid is precipitated as insoluble calcium ferrocyanide, and then redistilling. The purified oil of bitter almonds (Oleum Amygdalae Amarae, sine Acido Prussico) consists almost entirely of benzaldehyde and may justly be called natural benzaldehyde. It contains also traces of some other substances which are responsible for its finer odour and flavour as compared to synthetic benzaldehyde. The purified oil constitutes an important flavouring agent for use in pharmaceutical emulsions, confectioneries and candies; it has been used to conceal the taste of cod liver oil and castor oil. However, for the scenting of cosmetics, soap, and for use in perfumes, the much lower-priced synthetic benzaldehyde is now almost exclusively employed (U.S.D., 1955, 44; von Loesecke, 1942, 367; Guenther, V, 52–54).

Synthetic benzaldehyde is used as an adulterant for bitter almond oil. The kernels of apricot, peach,

cherry, and plum yield essential oils which are practically identical with the bitter almond oil. Bulk of bitter almond oil of commerce is now derived from apricot kernels which are lower-priced and yield a higher amount of oil (Guenther, V, 48; Tressler & Joslyn, 380).

Shells and Hulls—The almond shells (endocarp) have been used as adulterant for spices, and for fur cleaning and metal finishing. They have a calorific value of 8,364 B.t.u. and are employed as fuel in power houses. They are also used as poultry litter, mulching material for plants and as soil conditioner in agriculture. The shell is ground to powder and mixed with commercial fertilizers to provide bulk and improve their free-flowing characteristic. The shells of almonds as well as pits of apricots, cherry and peach are used in soft grit blasting for purposes of cleaning moulds and machine parts in various industries. Powdered shell charcoal is used tooth powder (Winton & Winton, I, 480, 485; Clark & Lathrop, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-352, 1953, 4, 20–22, 26, 32).

Almond hulls (fleshy pericarp) contain: moisture, 7.5; total sugars, 25.6; reducing sugars, 7.2; tannin, 4.4; protein, 2.6–4.7; starch, 1.6; pectin, 2.4; ether extr., 1.1–1.2; crude fibre, 12.6; and ash, 4.6–6.3%. They are reported to be suitable for the production of a table syrup, feed for livestock, and for tanning [*Chemurg. Dig.*, 1950, **9**(2), 13; *Chem. Abstr.*, 1948, **42,** 6471; *Sci. News Lett., Wash.*, 1947, **52,** 152].

Miscellaneous Uses—The tree exudes a gum which has been employed in place of tragacanth. It is obtained mostly from the trunk and larger branches of old trees which are adversely affected by its exudation. Almond gum hydrolyses into L-arabinose (4 parts), D-xylose (2 parts), D-galactose (3 parts) and D-glucuronic acid (1 part); aldobio-uronic acid is present (Smith & Montgomery, 275).

Almond flowers give 0.013 per cent of a concrete which yields 42 per cent absolute and 12 per cent essential oil. The concrete contains cresol, eugenol, caproic acid, phenylacetic acid, 1-decanol, geraniol, and phenyl ethyl alcohol, besides acetic acid in combined state. The leaves contain quercitin, cyanidin, kaempferol and caffeic acid (*Chem. Abstr.*, 1953, **47,** 7736; Bate-Smith, *J. Linn. Soc., Bot.*, 1961–64, **58,** 39).

The wood (wt., 689 kg./cu.m.) is dull reddish brown with darker veins and is said to be occasionally used in turnery and marquetry. The root of almond tree is said to be discutient and alterative (Howard, 18; Kirt. & Basu, II, 954).

TABLE 2—IMPORT AND EXPORT OF ALMONDS

(Qty in thousand kg. and Val. in thousand Rs.)

	Import		Export	
	Qty	Val.	Qty	Val.
1960–61	6,660	24,079	*	2.0
1961–62	3,925	16,674	2.0	2.5
1962–63	5,037	23,272	*	1.7
1963–64	3,422	16,694	2.0	2.3
1964–65	3,730	18,994	*	0.6
1965–66	3,660	20,577	38.5	285.4
1966–67	2,137	14,499		0.5
1967–68	4,244	26,746		0.5

* Small value transactions.

Trade—Large quantities of almonds are imported into the country every year. Afghanistan and Iran are the main supplying countries with Afghanistan supplying the major part of the total imports followed by Iran; Iraq, West Pakistan and Italy are some of the other countries which have supplied small quantities in some years. Table 2 gives the total quantity and value of almond imported into this country during the recent years. Very small quantities of almond and almond oil are also exported.

P. armeniaca Linn. COMMON APRICOT

D.E.P., VI(1), 344; C.P., 905; Fl. Br. Ind., II, 313.

HINDI—*Zardalu, khubani, chuari, kushmiaru.*

PUNJAB—*Hari, sari, chuli.*

A moderate-sized tree, about 10 m. tall, with a reddish bark, found almost naturalized in the north-western Himalayas, particularly in the valleys of Kashmir, Chenab, and Kulu and in Simla hills at altitudes up to nearly 3,000 m. Leaves ovate to round-ovate or sometimes sub-cordate, 5–9 cm. long; flowers pinkish white, borne singly and appearing much in advance of the foliage; fruits round, c. 5 cm. across, pubescent when young, but nearly glabrous at maturity, with a yellow skin overlaid with red; flesh yellow to yellowish orange, firm and sweet, mostly free from the flat, ridged stone; kernels sweet in some types and bitter in others.

The apricot is said to be a native of China and the central Asiatic region, from where it has spread to India, Iran, Egypt and Greece by way of Armenia. In Kinnaur (Himachal Pradesh) a recent census has shown that there are c. 72,000 wild trees, producing about 2,550 tonnes of fruit. The areas devoted to cultivation of apricot are: about 600 hectares in Kashmir,

375 hectares in Himachal Pradesh and 1,600 hectares in Kumaun; in these areas, some introduced types from America and Europe are cultivated. Apricot cultivation has not succeeded in South India (Chandler, 1957, 353; Zielinski, 129; Thapar, 110; Dang *et al., Indian Oilseeds J.*, 1964, **8**, 110; Hayes, 436; Information from the Directorate of Agriculture, Himachal Pradesh).

Apricot is grown in most countries of the temperate regions of the world. It is susceptible to frost and is cultivated only in warm temperate areas, where there is little danger from spring frost or severe freeze after warm spells. Commercially important apricot producing areas are: U.S.A., Spain, France, Italy, Turkey, Morocco, Iran, Africa, and Australia. Large proportion of the crop in trade is in the form of dried, frozen, canned, or pulped fruits (Hill, 391; Chandler, 1957, 353; *Fruits*, Commonwealth Econ. Comm., 1965, 59).

P. armeniaca includes a number of botanical varieties and cultivated types, some of them often considered as distinct species or sub-species. Among the important ones are: Black or Purple Apricot (*P. dasycarpa* Ehrh. syn. *P. armeniaca* var. *dasycarpa* Koch), Russian or Siberian Apricot (*P. sibirica* Linn.), Japanese Apricot (*P. mume* Sieb. & Zucc.), and Manchurian Apricot (*P. mandschurica* Koehne). All these yield fruits either small or of an inferior quality than *P. armeniaca*. Amongst these, *P. dasycarpa* is said to be grown in Kashmir and is considered to possess considerable hardness of wood and bud. It is supposed to be a hybrid between *P. armeniaca* and *P. cerasifera*. *P. sibirica* and *P. mandschurica* are reported to be more winter-hardy than *P. armeniaca*, *P. mandschurica* enduring as low a temperature as $-45°$. *P. mume* is grown more as an ornamental rather than for its fruit and is said to include double-flowered forms (Zielinski, 128; Rehder, 462; Mansfeld, 138).

Cultivated types of apricot are mostly introduced and have been successfully grown at varying elevations in the Himalayas. *New Large Early, Shipley Early, Charmaghz, Turkey, Moorpark, Kaisha, St. Ambroise* and *Royal* are types commonly cultivated in the hill districts of Uttar Pradesh, while *Kaisha, New Castle, Safeda Parachinar,* and *Ladakhi* are the popular types in Himachal Pradesh. In the last type, the fruit is said to dry on the plant. *Charmaghz* is a popular type with a sweet flesh. *Shipley Early, St. Ambroise* and *Royal* are also recommended for cultivation in Himachal Pradesh (Chadha, *Himachal Hort.*, 1960, **1**, 63; Sham Singh *et al.*, 341; Information from the Directorate of Fruit Utilization, Uttar Pradesh).

The apricot is said to be comparatively less rich than other species in the number of varieties and types available for breeding. All of them have $2n=16$ chromosomes. The various types are classified on three characteristics of the fruit, viz. sweet or bitter kernel, clingstone or freestone, and stone pervious or not. Some of the characteristics for which breeding has been done are: freestone, non-browning orange flesh, extended maturity season, winter-hardiness, larger fruit size and disease resistance. Some of the types or species from the eastern regions of U.S.S.R. are characterized by high sugar content of fruits and the capacity for dry-curing to a certain extent on the tree. Many of the apricot types introduced into cultivation are reported to have originated as chance seedlings. There are also a few, known as Plumcots and Cotplums, which are crosses with plum and some of these are said to be promising (Crane *et al., Yearb. Agric., U.S. Dep. Agric.*, 1937, 740; Zielinski, 130; Zhukovsky, *Euphytica*, 1965, **14**, 177; Chandler, 1957, 358).

Cultivation

The apricot thrives well in areas with moderate summer temperatures, at altitudes of 850–1,700 m. A porous, light but rich, well-drained loamy soil is said to be very suitable. Apricot plants are propagated by "T" or shield budding on wild apricot or peach or myrobalan plum rootstocks. Plum stock is said to adapt the plant for growth in wet or heavier soils while the other two stocks adapt the plant for lighter soils. The plants are set 6–8 m. apart in the autumn or early spring. Irrigation may be given in the early years of plantation, particularly in the dry season. Manurial requirements of apricots are similar to those of peach. The trees are pruned according to the modified central leader system. The apricot is said to be a rampant grower and is kept continuously in check by proper thinning of surplus shoots and shortening of new growth. When the fruit set is heavy, the crop is also thinned to leave not more than two or three fruits on each spur. Thinned crop is said to mature fruits more evenly and yield bigger fruits (Thapar, 110; Sham Singh *et al.*, 342; Chandler, 1957, 357; Gopalakrishna & Ekbote, *Punjab hort. J.*, 1962, **2**, 167).

Diseases and Pests—The apricot is said to be subject to coral spot of wood, caused by *Nectria*

cinnabarina (Tode) Fr., brown patch rot of leaf caused by *Phyllosticta prunicola* (Opiz) Sacc., spongy heart rot caused by *Polyporus hispidus* (Bull.) Fr., and a brown rust, caused by *Puccinia pruni-spinosae* Pers. But none of these is said to be serious. Bacterial gummosis or canker, caused by *Pseudomonas* sp. is a serious disease reported on the apricot and other stone fruits like the cherry, peach and plum. Cankers appear on the trunk, branches and fruits, exuding large drops of gum. Field trials for control of this disease are said to be under progress, but the only measure available at present is the removal and burning of all infected wood as soon as the infection appears (*Indian J. agric. Sci.*, 1950, **20**, 107; Thapar, 112; Agarwala, *Himachal Hort.*, 1961, **2**, 49; Anderson, 245–49).

The weevil, *Emperorrhinus defoliator* Marshall is said to become sometimes a serious local pest of fruit trees in Kulu. The chafer beetle, *Anomala polita* Blanchard, is said to damage the shoots and leaves. The caterpillars of the moth *Lymantria obfuscata* Wlk., sometimes completely defoliate the plant. A number of pests of the dried fruit, like the saw-toothed beetle *Oryzaephilus* (*Silvanus*) *surinamensis* Linn., and the Chalcid, *Eurytoma samsonowi* Vasiljev and others of lesser importance have been recorded. The latter species is a serious pest in West Pakistan and adequate quarantine measures are necessary on land routes to prevent its entry into India [Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 4; Sharma & Surender Kumar, *Himachal Hort.*, 1965, **6**(2–3), 5].

In common with other stone fruit crops the apricot also is sometimes badly affected by sun scald. Tying straw all round the main trunk and pruning so as to induce low heading are said to be some of the preventive measures (Singh, *Indian Fmg*, 1944, **5**, 73).

Harvesting—The apricot is self-fertile. The tree starts bearing when it is 4–5 years old and continues to bear well for 30–35 years, the yield of a full bearing tree varying from 35 to 75 kg. The problem of pre-harvest fruit drop is said to be very serious in apricot and spraying with suitable chemicals is recommended as a preventive measure. The fruit is harvested from May to July, when it has attained its characteristic colour but is still firm enough to withstand transport. The apricot crop ripens unevenly and has to be harvested three or four times in order to obtain mature and best flavoured fruit. Thinned crop is said to mature fairly evenly, besides yielding bigger fruits. Picking is done by hand and the practice of shaking ripe fruit from trees is not recommended as the fruits are likely to get blemished or damaged [Thapar, 112; Sham Singh *et al.*, 343; Gopalakrishna & Ekbote, loc. cit.; Tressler & Joslyn, 583; Balbir Singh, *Indian Hort.*, 1962–63, **7**(2), 16].

Utilization and Chemical Composition

The apricot is used as a table fruit in the regions where it is grown. It is highly perishable and is preserved for use in a number of ways. In U.S.A., South Africa and Iran where the fruit is cultivated on a large scale, large quantities of apricot are canned or dried. They are also frozen, candied or made into a paste. In India, small quantities of apricot are processed in Uttar Pradesh (Table 3). In some countries, apricot pulp is cooked and thinly spread on cloth and then rolled and dried, and in this form is said to constitute an important food. Fruits of wild apricot (*Zardalu*) mixed with those of cultivated types are utilized in Himachal Pradesh in the production of a number of products like apricot jam, apricot nectar and apricot *papad*. In the preparation of *papad*, the fruit is made into pulp which is then dehydrated and pressed. The fruit of the wild apricot is also eaten fresh, or is preserved by drying after separating the pits.

The kernels extracted from the pits during preparation of dried apricots are a valuable by-product. They are utilized to express an oil used locally for cooking and burning. The kernels of some types of apricot known also as Chinese almonds are sweet and are eaten like almond kernels. The kernel oil is also used as a substitute for almond oil. The cake left after pressing out the oil is used as manure or fuel. The cake is also a source of an essential oil identical with that obtained from bitter almond cake (q.v.) (Hill, 378; Thapar, 112; Information from the Directorate of Horticulture, Himachal Pradesh; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 100; Porterfield, *Econ. Bot.*, 1951, **5**, 30; Kester, ibid., 1951, **5**, 38; Zielinski, 130).

TABLE 3—QUANTITY OF SOME STONE FRUITS USED FOR PROCESSING IN UTTAR PRADESH*
(in kg.)

	1964–65	1965–66	1966–67
Apricot	25,962	20,505	7,445
Peach	10,978	16,483	10,222
Plum	11,576	4,298	1,570

* Based on data from Messrs Kissan Products Ltd., Bareilly, U.P., and the Govt. Fruit Processing Factory, Ramgarh (Naini Tal), U.P.

Apricot is a good source of sugars and vitamin A, and contains appreciable amounts of thiamine and iron. Fresh Indian apricots yield 86 per cent of edible matter which contains: moisture, 85.3; protein, 1.0; fat (ether extr.), 0.3; fibre, 1.1; other carbohydrates, 11.6; and mineral matter, 0.7%; calcium, 20 mg.; phosphorus, 25 mg.; iron, 2.2 mg.; vitamin A value, 3,600 I.U.; thiamine, 0.04 mg.; riboflavin, 0.13 mg.; nicotinic acid, 0.6 mg.; ascorbic acid, 6 mg.; and calories, 53/100 g. The average ascorbic acid values of some important types of apricots grown in Chaubattia (Uttar Pradesh) are: *Kaisha*, 8.1; *Moorpark*, 4.6; *Parine Apple*, 6.9; and *Turkey*, 6.0 mg./100 g. The fruit contains iodine (0.48 μg./100 g.) (Tressler & Joslyn, 447–50; Nutritive Value of Indian Foods, 66, 101, 131; Srivastava & Srivastava, *Sci. & Cult.*, 1965, **31,** 140; Iodine Content of Foods, 96).

Ripe fruit pulp contains: total solids, 12.4–16.7; insol. solids, 2.1–3.1; acids (as malic acid), 0.7–2.2; total sugars (as invert sugar), 5.3–8.6; glucose, 3.2–4.8; fructose, 1.4–4.2; sucrose, 1.4–5.4; and tannin, 0.06–0.10%. The sugars and polyols include xylose, glucose, fructose, sucrose, sorbitol, meso-inositol, and a number of oligosaccharides composed of glucose and fructose units. Reducing sugars increase rapidly as the fruit ripens on the tree; appreciable amounts of sucrose occur only in the fully ripe fruit. The fruit also contains pectic substances (1%, as calcium pectate). Malic and citric are said to be the principal acids. Presence of tartaric, quinic, and succinic acids is also reported. Samples of Indian apricots, obtained from Chaubattia and from the Lucknow market, were found to contain citric as the major acid, while malic acid was absent. Invertase, amylase and emulsin occur in the fruit at all stages of ripening. The free amino acids identified in apricots are: aspartic acid, glutamic acid, threonine, serine, proline, alanine, glycine, valine, leucine (or *iso*leucine), cystine, phenylalanine, tyrosine, γ-amino butyric acid, histidine, arginine, glutamine, and β-alanine (Winton & Winton, II, 246–48; Reynolds, *Aust. J. Chem.*, 1957, **10,** 198; Ash & Reynolds, ibid., 1955, **8,** 444; Kertesz, 292; Agarwal & Date, *J. Fd Sci. & Technol.*, 1966, **3,** 70; Thorpe, I, 453).

The volatile essence of apricot includes myrcene, limonene, *p*-cymene, terpinolene, trans-2-hexenol, α-terpineol, geranial, geraniol, 2-methylbutyric and acetic acids, linalool, the *cis*- and *trans*-isomers of an epoxydihydrolinalool, γ-octalactone, and γ-decalactone. The typical apricot aroma appears to be due to an integrated response to the proper ratios of these compounds (Tang & Jennings, *J. agric. Fd Chem.*, 1967, **15,** 24).

A number of products are prepared from apricots. Strained baby food prepared from the pulp is nutritious and a good source of calcium, phosphorus and iron. Apricot nectar, a popular beverage, is prepared by steaming and converting the ripe soft fruit into puree and mixing it with sugar syrup containing some citric acid. Apricot beverages have low acidity and therefore tend to be somewhat flat; they blend particularly well with more acid fruit juices, such as orange or pineapple. Apricot leather (*Kamaradin*), extensively used in drinks and sauces in the Middle East, is prepared by drying the pulp after treatment with sulphur dioxide as preservative and mixing the same with sucrose (5%) and glucose syrup (5%). The golden coloured product is highly nutritious and has a vitamin A potency of 7,000 I.U./100 g. (Siddappa & Ranganna, *Food Sci.*, 1961, **10,** 29; Tressler & Joslyn, 816–17; Grncarevic, *Food Technol., Aust.*, 1965, **17,** 519).

Dried Apricot—Apricots are dried either in the sun or artificially after pitting and sulphuring. The Chini area of Himachal Pradesh where this crop is being cultivated is said to be suitable for producing dried apricots. For drying, fruits at eating ripe stage are selected. They are then washed, slit open, removed, and then loaded into a sulphur house that may be constructed out of mud and other local materials. The fruit is allowed to remain in the sulphur house for 12–24 hours after the sulphur has ceased to burn and then dried in the sun for about 100–120 hours; the dried product is stored in clean cloth bags and hung or stored in a cool dry place. Standards have been suggested for three grades of dried apricots, viz. Fancy, Choice and Standard [Christie & Barnard, *Indian Fd Packer*, 1956, **10**(7), 11; 1956, **10**(8), 9; Eddy, *Punjab Fr. J.*, 1957, **21**(77), 1; Eddy & Shafiq, ibid., 1958–59, **22**(78), 18].

Analysis of edible matter (93% of fruit) of dried Indian apricots gave: moisture, 19.4; protein, 1.6; fat (ether extr.), 0.7; fibre, 2.1; other carbohydrates, 73.4; and mineral matter, 2.8%; calcium, 110 mg.; phosphorus, 70 mg.; iron, 4.6 mg.; vitamin A value, 98 I.U.; thiamine, 0.22 mg.; nicotinic acid, 2.3 mg.; ascorbic acid, 2 mg.; and calories, 306/100 g. (Cruess, 453; Girdhari Lal *et al.*, 141–42; Thorpe, I, 453; Nutritive Value of Indian Foods, 66, 101, 131).

Apricot Kernel—The apricot pits (6–11% of the fruit) yield 22–38 per cent kernels, which may be

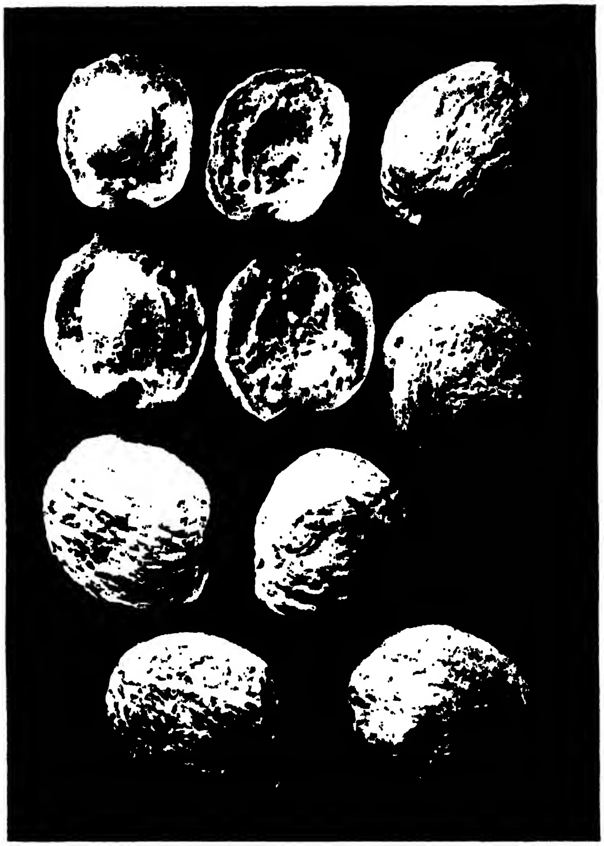


FIG. 95—PRUNUS ARMENIACA—DRIED APRICOT FRUITS WITH SEED

sweet or bitter, depending upon the type. Sweet kernels resemble almond in taste and are used as its substitute in pastes and confectionery and can be added to apricot jam. An analysis of the kernels gave: water, 4.3; protein, 31.4; oil, 53.4; sugar as dextrose, 8.1 (direct) and 11.6 (after conversion); fibre, 4.8; and ash, 2.6%. Samples of two types, one of sweet kernels (*Morpankha*) and other of bitter kernels (*Chawaru*) from Kumaun, contain 44–45 per cent fat and 20–21 per cent protein [Thorpe, I, 453; Dhar & Chauhan, *Agra Univ. J. Res.* (*Sci.*), 1963, **12**, 9; Winton & Winton, I, 489; II, 644; Girdhari Lal *et al.*, 257; Dang *et al.*, *Indian Oilseeds J.*, 1964, **8**, 110].

The fatty oil, extracted from the apricot kernels, is an important article of commerce. The kernels are coarsely ground and heated with steam to the temperature of boiling water before pressing them in expellers or hydraulic presses. The expressed oil is refined by screening to remove the solid material, treating with sodium carbonate to neutralize free acids, decolourizing with fullers' earth or activated carbon, and finally heating with steam in vacuum. The refined oil is almost colourless and is of agreeable flavour and odour. Table 1 (p. 255) gives the usual range of characteristics of the oil. A sample of light pale-yellow oil obtained from the Indian bitter apricot kernels, showed the following fatty acid composition: myristic, 1.1; palmitic, 3.5; stearic, 2.0; oleic, 73.4; and linoleic, 20.0% (Cruess, 588–89; Dang *et al.*, loc. cit.).

Apricot kernel oil closely resembles expressed almond oil and is employed as an adulterant or substitute for it. The French almond oil of commerce is practically pure apricot oil or its mixture with peach kernel oil. Apricot kernel oil is used for food purposes and in cosmetics and pharmaceutical preparations. It sells at a higher price than most other food oils, but at a lower price than almond oil. It also finds use in medicine for earache and other ailments. In Kinnaur area of Himachal Pradesh, where large quantities of wild apricots are collected, crushing of kernels is reported to be an important industry, though exact figures of oil production are not available. With the development of the apricot processing industry in the Naini Tal district of Uttar Pradesh, the kernels would be available in quantities and serve as a possible source of edible of [Krishna *et al.*, *Indian For. Rec.*, *N.S.*, *Chem.*, 1936, **1**(1), 27; Eckey, 458; Jamieson, 171; Information from Directorate of Horticulture, Himachal Pradesh; Dang *et al.*, loc. cit.].

The cake left after extraction of the oil contains amygdalin and is therefore unfit for use as cattle feed; it yields 0.06 per cent of hydrocyanic acid. The cake is utilized as a fuel and as fertilizer. It contains: nitrogen, 6.64; phosphoric acid (P_2O_5), 2.2; and potash (K_2O), 1.14%. An essential oil which is identical with bitter almond oil (q.v. *P. amygdalus*) is distilled from the cake. Apricot kernels are cheaper and give higher yields of oil (0.8–1.6%) than bitter almond kernels and are the main source of the bitter almond oil of commerce. The seed cake of the bitter apricot (*Chawaru*) yields 1.6 per cent of the oil. The cake from which the oil has been removed is free of hydrocyanic acid and can be used as a feedstuff for livestock (Lal Singh *et al.*, *Indian J. agric. Sci.*, 1951, **21**, 139; Das, ibid., 1945, **15**, 30; Jamieson, 172; Guenther, V, 48).

The pit shells have been used for the preparation of activated carbon. High quality charcoal for use in case-hardening or heat treatment of steels by

carburizing is obtained by destructive distillation of the shells (Clark & Lathrop, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-352, 1953, 4, 30).

Apricot leaves contain quercitin, cyanidin, kaempferol, caffeic acid and *p*-coumaric acid (Bate-Smith, *J. Linn. Soc., Bot.*, 1961–64, **58**, 39).

The wood (wt., 785 kg./cu.m.) which is greyish brown, moderately hard and mottled with dark brown streaks, is used for various purposes in the hills of Punjab: in some places it is said to be the chief firewood (Gamble, 312).

Trade Some quantities of dried apricots were being imported from Afghanistan prior to World War II. Because of the poor quality they had to be reprocessed and a method was evolved and standardized for this purpose. Very small quantities of apricots, both fresh and preserved, are exported. There was, however, some export of apricot kernels during the period 1960–61 to 1965–66, the quantity exported reaching a peak figure of about 370,000 kg. valued at c. Rs. 1,380,000 during 1962–63. The U.K., Italy and many other European countries, U.S.A., Hongkong and South Viet Nam were the chief importing countries. Varying quantities of both fresh and dried apricots are imported annually, the imports coming mainly from Afghanistan. Tables 4 and 5 give details of exports and imports of apricots, respectively, during the period 1960–61 to 1967–68.

TABLE 4—EXPORTS OF APRICOTS AND OTHER STONE FRUITS FROM INDIA

(Qty in kg.)

	1960 61 to 1962 63*	1963–64	1964 65	1965-66	1966–67	1967-68
Fresh fruits						
Apricots	7,500	20	577	51,600	7,500	5,100
Cherries	300	264	..	..	..	..
Peaches	350	1,255	4,990	5,000	..	..
Plums	12,500	13,275	5,611	..	..	..
Total Qty (kg.)	20,650	14,814	10,178	56,000	7,500	5,100
Total Val. (Rs.)	25,100	9,896	23,215	79,285	15,600	15,972
Preserved fruits						
Apricots and Plums						
Quantity (kg.)	7,250	8,038	14,000	22,380	178	158
Value (Rs.)	22,000	27,932	37,253	33,452	1,429	1,650
Apricot kernels						
Quantity (kg.)	162,200	119,957	54,429	4,870	..	..
Value (Rs.)	573,300	383,635	123,310	9,745	..	..

* Average of three years.

TABLE 5—IMPORTS OF APRICOTS AND OTHER STONE FRUITS INTO INDIA

(Qty in kg.)

	1960 61 to 1962-63*	1963–64	1964 65	1965 66	1966 67	1967 68
Fresh fruits						
Apricots	112,000	26,097	34,064	11,543	14,701	940
Peaches	580,000	249,258	..	78,850	..	..
Plums	2,235,000	3,605,130	..	1,142,189	..	65,025
Total Qty (kg.)	2,927,000	3,880,485	84,064	1,232,582	14,701	65,965
Total Val. (Rs.)	1,199,000	895,291	153,015	569,508	57,102	246,620
Dried fruits						
Apricots	..	..	..	647,882	65,860	266,482
Plums and Prunes	63,000	317,000	44,000	13,116	2,033	5,483
Total Qty (kg.)	63,000	317,000	44,000	660,993	67,893	271,965
Total Val. (Rs.)	248,000	877,083	95,496	1,606,139	180,311	879,486

* Average of three years.

P. avium Linn. SWEET CHERRY

D.E.P., VI(1), 346; Fl. Br. Ind., II, 313.

KUMAUN—*Gilas, krusbal.*

A tree, up to 24 m. high, erect or pyramidal in habit; leaves oblong-ovate, 6–15 cm. long, acutely serrate: flowers in fascicles, white, long stalked, appearing with the leaves: fruits round, smooth, yellow, red or nearly black, 0.6–1.25 cm., flesh soft or firm, sweet or bitter.

The sweet cherry has been divided by botanists into different groups, but because of hybridization amongst the various types it is rather difficult in many cases to classify them. They are commonly classified as: var. *avium* (MAZZARD); var. *juliana* (Linn.) Schubler & Martens (HEART CHERRY, GEAN CHERRY); and var. *duracina* (Linn.) Schubler & Martens (BIGARREAU).

Var. *avium* is considered to be the wild form of the species with small, purple-black, sweet fruits. In var. *juliana* the fruits are heart-shaped, soft-fleshed and of sweet flavour with a reddish or colourless juice. Var. *duracina* includes forms with firm-fleshed and often heart-shaped fruits. DUKE CHERRIES, formerly included as a variety of *P. avium*, are now thought to be hybrids of *P. avium* with *P. cerasus* (SOUR CHERRY) (Mansfeld, 142; Zielinski, 136; Rehder, 474; Chandler, 1957, 391).

The sweet cherry is believed to be indigenous to southern and central Europe and western Asia. Cherry culture is an important industry in Germany, France, Czechoslovakia, Poland and Italy and some other southern European countries and also in U.S.A. In India, it is cultivated in Kashmir, Simla hills and Kulu valley and does best at elevations of 1,500–2,000 m. and above. The area in Kashmir under sweet and sour cherries together is reported to be about 400 hectares; about 18 hectares are said to be under this crop in Uttar Pradesh and about 45 hectares in Himachal Pradesh. A large number of types of the sweet cherry have been tried successfully in these areas and the chief amongst them are: *Bigarreau, Black* (*Merton*) *Heart, Bedford Prolific, Elton, Early Rivers, Emperor Francis*, and *Governor Wood* [Marshall, 1; Sham Singh *et al.*, 344; Hayes, 439; Chadha, *Himachal Hort.*, 1960, **1**, 63; Kirpal Singh & Jawanda, *Indian Hort.*, 1963–64, **8**(1), 15].

The sweet cherry is a diploid species with 2n=16 chromosomes and has been crossed with the sour cherry (*P. cerasus*) which is a tetraploid (2n=32). The offsprings from these crosses are, however, highly sterile. The Duke Cherries which combine characters of these two species are also tetraploids and are self fruitful. They are probably derivatives of hybridization of an unreduced germ cell of *P. avium* with a normal reduced germ cell of *P. cerasus*. One of the main objectives in cherry breeding is the production of high quality types that are more hardy than those available now, and types with fruits which have a firm flesh and do not crack and will ripen over a long period. All existing types of the sweet cherry are said to be self-incompatible. A few self-compatible mutants have been obtained recently through treatment with X-rays. A dwarf mutant has been recently obtained and its use as a dwarfing stock for sweet cherry types is said to be promising (Cullinan, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 727–28, 734–36; Crane & Lawrence, 192, 212, 220; Chandler, 1957, 392; Williams & Brown, *Endeavour*, 1960, **19**, 147).

The sweet cherry is exacting in its climatic and soil requirements. It blossoms early in the spring and the flowers are very susceptible to cold and frost injury. The period from flowering to fruit ripening should be free from rain as otherwise fruit setting is hindered or the fruits split before ripening. The soil should be well drained, deep and fertile and with a good moisture content (Thapar, 98; Philp, *Circ. Calif. agric. Ext. Serv.*, No. 46, 1947).

The cherry is propagated by budding or grafting. The seedlings of *Prunus cerasoides* (*Paja*) are commonly used as rootstock in this country, the grafting being done in January, by whip or tongue method. In U.S.A. three different rootstocks are used for propagation of the sweet cherry according to the type of tree required. Seedlings of the wild cherry type *Mazzard* are very widely used. Seedlings of *P. mahaleb* are sometimes preferred as they are resistant to some diseases and pests of the cherry, but this rootstock is said to dwarf the plant. Some types of the sour cherry (*P. cerasus*) are also used as rootstocks as they resist wet, poorly aerated soils better than other stocks (Bajwa *et al.*, *Indian J. Hort.*, 1959, **16**, 18; Thapar, 98; Chandler, 1957, 390; Shoemaker & Teskey, 287; Bailey, 1947, I, 739; Philp, loc. cit.).

Cherry trees grow to a considerable size and are planted at distances of 7.5–9.0 m. or more depending upon the type of the tree planted and fertility of the soil. Since all or most types of sweet cherry are self-incompatible and some are intersterile as well, and since the different types come to harvest at different periods, single rows of selected compatible types may have to be suitably interplanted. If facilities for irrigation are available, the newly planted trees may be

irrigated for a year or two. Application of about 75 kg. of farmyard manure and 3–4 kg. of ammonium sulphate per bearing tree may be applied in two doses, one before flowering and the other after fruit set. Fruit is borne laterally on spurs which are productive for 10–12 years and because of this persistent fruit spur system, cherry trees require comparatively less pruning. The modified leader tree with well spaced branches is advisable (Thapar, 99–100; Sham Singh *et al.*, 344; Chandler, 1957, 386; Shoemaker & Teskey, 301–13; Chittenden, I, 456–57).

The cherry does not suffer from many diseases and pests in India. Leaf spot caused by *Cercospora rubrotincta* Ell. & Ev. is reported from Kashmir: small circular reddish brown spots appear on the leaves and in severe cases early defoliation of the tree may follow. Spraying with Bordeaux mixture is effective as a prophylactic measure. Tatter leaf disease caused by a virus is said to be common in the hilly regions of Himachal Pradesh and Punjab both on cherries and on peaches. The grub of *Aeolesthes holosericea* Fabr. bores into the stem of the plants in Punjab. The beetles *Protoaetia impavida* Janson and *Stalagosoma albella* Pallas have been recorded from Punjab and Kashmir as fairly serious pests of the blossom. The beetles *Mimela passerinii* Arrow and *Anomala flavipes* Arrow and the weevil *Myllocerus lefroyi* Marshall may damage the foliage (Kaul, *Curr. Sci.*, 1962, **31**, 29; Nagaich & Vashisht, *Indian Phytopath.*, 1965, **18**, 288; Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 27–28; Thapar, 101).

The ripe fruits of the sweet cherry like those of *Emperor Francis*, being grown in some areas of Himachal Pradesh, are liable to crack under rainy or foggy conditions. Excess of water in the cells is said to be the cause of cracking. Spraying the trees with Bordeaux mixture or hydrated lime before harvest or application of borax to soils deficient in available boron are some of the treatments that help in controlling cracking. Shaking the water off the branches mechanically after rains also reduces cracking to some extent (Information from Directorate of Horticulture, Himachal Pradesh; Marshall, 60–63; Shoemaker & Teskey, 332–34).

The various types of cherries come to harvest from the beginning of May to early July. Fruits can be picked when they attain a solid light red colour, but fruits of the firm-fleshed types that turn black when fully ripe on the tree can be picked later when they develop a bright dark red colour. Because of their small size, cherry harvesting and packing are relatively expensive. The fruits are picked with the pedicels attached and packed in small baskets of 2–4 kg. capacity or in small boxes containing 4.5–9.0 kg. of fruit (Thapar, 101; Marshall, 148; Philp, loc. cit.).

Cherry trees come to bearing in their fourth or fifth year but optimum yields are obtained after ten years. They continue to bear for 40–60 years. The average annual yield is 9–18 kg. per tree (Thapar, 101).

Utilization and Chemical Composition—Sweet cherries (*P. avium*) are used as dessert and the sour cherries (*P. cerasus*) for cooking. They are very perishable and large quantities are preserved by canning, brining, freezing, or sun drying. In the case of small types of sweet cherries and most of the sour cherries the fruits are pitted before canning. In other cases the fruits are canned without pitting, as the retention of the pits adds to the appearance for dessert purposes and also imparts a distinctive flavour. The fruits are canned in syrup in special cans that can resist corrosion.

Large quantities of cherries are brined with solutions of 1.5 per cent sulphur dioxide and 0.9 per cent calcium carbonate or hydroxide. Brined cherries are used in fruit salads, fruit cocktails, ice-cream, and baking products. For candying, the brined cherries are cleaned, coloured with a suitable dye and treated with increasingly concentrated sugar syrups till the water in the fruit is replaced with syrup of sufficient concentration. They are finally glazed.

Cherries are also frozen. Sour cherries are preferred to the sweet kinds for preservation by freezing. Cherries can be preserved by sun drying or dehydration and are then suitable for cooking. Cherries are dried after treatment with lye solution and sulphur; fruits pitted before dehydration are not dipped in lye solution. A number of standards and grades have been established in U.S.A. for both fresh and processed cherries.

Cherry juice is obtained from fresh or frozen cherries. Juice obtained from sour cherries is usually too sour as such and requires sweetening with sugar syrup, while that obtained from sweet cherries is somewhat lacking in acidity and also in colour. The juice from sweet and sour varieties judiciously mixed yields an attractive product with or without the addition of sugar. Carbonated cherry juice is a very pleasing beverage. Cherry syrup may be prepared by concentrating cherry juice. A liquor of high alcohol content (Kirschwasser) is distilled from fermented

sweet cherries (Hill, 392; Marshall, 187-269; von Loesecke, 1942, 55-56, 429, 431, 468; Cruess, 376-80, 494; *Yearb. Agric., U.S. Dep. Agric.*, 1950-51, 592; Tressler & Joslyn, 701-06; Thorpe, III, 25).

Cherries are fairly high in sugars and ascorbic acid, and contain appreciable amounts of vitamin A and most minerals. Average composition of the flesh (94-95% of the whole fruit) of cherries grown in U.S.A. is as follows: moisture, 83.0; protein, 1.1; fat, 0.5; fibre, 0.3; other carbohydrates, 14.5; and mineral matter, 0.6%; calcium, 18 mg.; phosphorus, 20 mg.; iron, 0.4 mg.; vitamin A value, 620 I.U.; thiamine, 0.05 mg.; riboflavin, 0.06 mg.; niacin, 0.4 mg.; and ascorbic acid, 8.0 mg./100 g. During ripening of cherries, there is an increase in sugars and non-sugar solids, and a decrease in acidity, tannin, and astringency. Enzymes invertase and amylase are present at all stages of growth. Analysis of ripe *Black Heart* and *Governor Wood* types of Indian sweet cherries, collected in Chaubattia (Almora), gave the following average values, respectively: moisture, 77.0, 80.5; soluble solids (mostly sugars), 19.5, 16.5; and total acids (as malic), 0.50, 0.69%; ascorbic acid, 19.8, 17.5 mg./100 g. Malic is the principal acid in cherries; small amounts of citric, tartaric and succinic acids are also reported. Sugars in cherries consist mainly of glucose and fructose, with sucrose as a minor component. Pectic substances occur in small amounts. Methyl anthranilate and methyl salicylate are the flavouring constituents identified in cherry juice. Keracyanin chloride, the colouring principle of cherry skin, appears to be a diglucoside of cyanidin (Watt & Merrill, *Agric. Handb., U.S. Dep. Agric.*, No. 8, 1950, 21; Winton & Winton, II, 660, 662; Shah, *Sci. & Cult.*, 1965, **31,** 631; Srivastava & Agarwal, *Punjab hort. J.*, 1964, **4,** 157; Thorpe, III, 251; Tressler & Joslyn, 451, 702; Kertesz, 299; Naves & Mazuyer, 182).

Sweet cherry pits contain 16-33 per cent kernels which yield 35.3-43.3 per cent of an edible oil, similar to that from sour cherry pits. The bark contains tannins up to 16 per cent. The stems of the sweet cherry and the sour cherry are reported to contain a non-toxic principle useful in certain heart diseases. The fruit stalks are considered tonic and astringent but rarely used (Winton & Winton, I, 495; Howes in Wiesner, Lieferung 1, 257; *Chem. Abstr.*, 1962, **56,** 11716; Kirt. & Basu, II, 959; Wren, 78).

The wood (wt., 528-785 kg./cu.m.) which is light red or pink when first cut, darkens on exposure to a pleasing tone resembling mahogany. It has a close, firm texture and is capable of a very smooth surface. It closely resembles mahogany when stained with lime and then oiled and varnished, and is suitable for the making of high class furniture (Howard, 139; Handbook of Hardwoods, 70).

P. cerasifera Ehrh. syn. *P. domestica* var. *myrobalan* Linn. MYROBALAN PLUM, CHERRY PLUM

Bailey, 1949, 539; Rehder, 456.

A small slender twiggy tree, sometimes thorny; leaves ovate to obovate, finely serrate, *c.* 5 cm. long; flowers white, *c.* 2.5 cm. across, borne singly or two or three together; fruits small, up to 2.5 cm. in diam., globular, red or yellow, with soft, sweet flavoured juicy flesh.

This species, said to be indigenous to the Caucasus and south-western Asia, is considered to be one of the parents of the common plum (*P. domestica*). It has a chromosome complement of 2n=16, and the ground colour of the fruit is generally yellow while the sap colour is red. It is but little cultivated for fruit, but is highly prized as a stock upon which to grow other stone fruits, particularly *P. domestica*. It is being tried for this purpose in India also (Zielinski, 144; Chandler, 1957, 340; Bailey, 1947, III, 2825; Thapar, 102).

The myrobalan plum has been crossed with types of Japanese plums (*P. salicina*) to produce a number of promising hybrids characterized by high yield and fruit quality. It has also been crossed with the peach, and almond. The hybrids are sterile, but their pollen is fertile. Some of these hybrids are said to show some promise as rootstock for the peach (*Plant Breed. Abstr.*, 1956, **26,** 290; Garnaud, II, 74).

P. cerasifera var. *pissardii* Koehne, a small tree with rich purple leaves and bluish tinged white blossoms appearing in profusion, is reported to be cultivated as an ornamental (Fl. Assam, II, 183; Krishnamurthi, 223).

P. cerasoides D. Don syn. *P. puddum* Roxb. ex Brandis non Miq. HIMALAYAN WILD CHERRY

D.E.P., VI(1), 350; C.P., 907; Fl. Br. Ind., II, 314.

HINDI—*Paddam, phaya*; BENG.—*Padmak*; MAR.—*Padma kastha, padmaka*; GUJ.—*Padma kathi*.

PUNJAB—*Paja*; ASSAM—*Dieng-soh-iong-krem*.

A middle-sized or large tree indigenous to the temperate Himalayan region, extending from Kashmir to Bhutan and in Aka and Khasi hills in Assam and in Manipur at altitudes of 900-2,300 m. Bark smooth, brown, peeling off in horizontal strips exposing a shining copper-coloured surface; leaves variable in

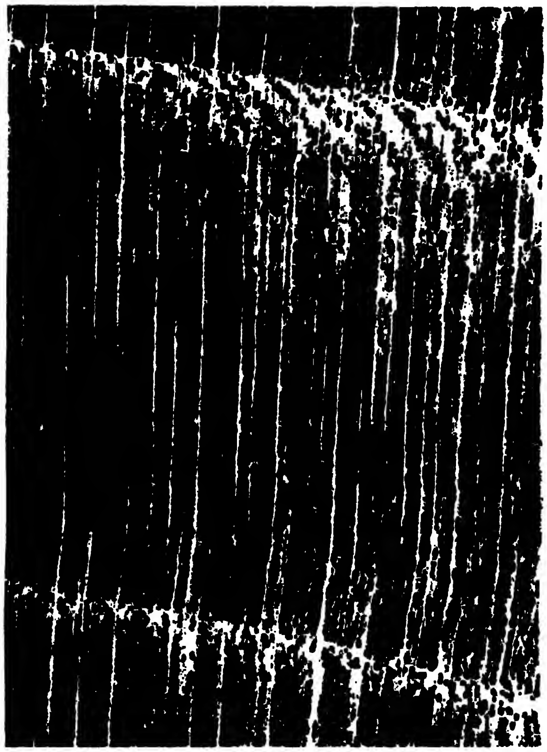
FIG. 96—PRUNUS CERASOIDES—FLOWERING AND FRUITING BRANCHES

length and breadth, doubly serrate; flowers in fascicles or umbels, rose-red to white; drupes ovoid, c. 1.25 cm. long, yellow or reddish.

This species is very variable, comprising a number of more or less distinct geographical races. Two varieties grow in some areas like the Darjeeling hills, one being very large, up to 27 m. high, with crimson or rose-pink flowers which appear in March, and the other often cultivated, a small or medium-sized tree about 11 m. high, with deep pink flowers which appear in October–November soon after the rains. The former is now designated as var. *rubens* Ingram and the latter as var. *majestica* Ingram. The tree reproduces freely from root suckers and can be grown from cuttings. The seeds of this species germinate readily and the seedlings are used as rootstock for the propagation of the sweet cherry in this country (Troup, II, 487; Ingram, *Gdnrs' Chron.*, 1947, **122,** 162; Thapar, 98; Bajwa, *Indian J. Hort.*, 1959, **16,** 18).

The sapwood is whitish and lustrous; the heartwood (av. wt., 720 kg./cu.m.) is reddish brown, close-grained, moderately hard and strong, durable, and seasons well. It is resistant to fungus and insect attack and works to a good finish. Except in Sikkim, the supplies of this wood are rather small. It is occasionally used for buildings and for making ornamental furniture. The wood of saplings, branches and root suckers makes excellent walking sticks and umbrella crooks. It deserves attention as a turnery wood and also as a suitable alternative to walnut (*Juglans regia*) in the manufacture of gun stocks (Pearson & Brown, I, 475; Gamble, 313; *Indian For.*, 1952, **78,** 367).

The fruits which are produced in abundance have scanty pulp and are scarcely eaten, but are said to be used to make a well known cherry brandy. The kernels contain an oil similar to that of bitter almonds and with a strong flavour of prussic acid. The kernel is used as a remedy for stone and gravel. The leaves, twigs, bark and kernels contain a cyanogenetic substance. The bark is used for tanning. The smaller branches are crushed and soaked in water and taken internally to stop abortion (Kirt. & Basu, II, 959; Biswas, 52; Chopra *et al.*, I, 365; Chopra, 1958, 521).



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 97—PRUNUS CERASOIDES—TRANSVERSE SECTION OF WOOD (×10)

The stem bark contains flavonone sakuranetin (1%), flavone genkwanin, *iso*flavone prunetin, and *iso*-flavonone padmakastein, along with smaller quantities of the glycosides sakuranin and padmakastin. Sakuranin is the 5-glucoside of sakuranetin (5, 4′-dihydroxy-7-methoxyflavone) which on dehydrogenation yields genkwanin. Padmakastin is the 4′-glucoside of padmakastein which is found to be hydroprunetin. Later work has shown that sakuranin is accompanied by the corresponding chalkone glycoside named neosakuranin (2, 4′-dihydroxy-4-methoxy-6-glucosidoxy chalkone). The bark also contains a small amount of taxifolin. A dihydroflavonol padmatin, and its precursor taxifolin are reported in the heartwood (Chakravarti & Ghosh, *J. Indian chem. Soc.*, 1944, **21,** 171 ; Narasimhachari & Seshadri, *Proc. Indian Acad. Sci.*, 1949, **30A,** 271 ; 1952, **35A,** 202 ; Ramanujan & Seshadri, ibid., 1958, **48A,** 175 ; Puri & Seshadri, *J. sci. industr. Res.*, 1954, **13B,** 698 ; McIlroy, 40 ; Goel & Seshadri, *Tetrahedron*, 1959, **5,** 91).

The tree yields an abundant gum (Gamble, 31).

P. cerasus Linn. SOUR CHERRY, RED CHERRY, DWARF CHERRY

D.E.P., VI(1), 346 ; C.P., 906 ; Fl. Br. Ind., II, 313.

PUNJAB—*Gilas, olchi, jera-sayna.*

A small tree, usually round-topped or spreading, bearing root suckers ; leaves ovate, hard, stiff and rather abruptly pointed, minutely toothed ; flowers white, in clusters of 2–5 on slender pedicels, appearing with the leaves ; fruits globose, 0.6–1.25 cm. in diam., light red to nearly black, acid or sweet.

This species includes three varieties, viz. var. *cerasus* (AMARELLE CHERRY), var. *austera* Linn. (MORELLO CHERRY), and var. *marasca* Vis. (MARASCA CHERRY). Of these, *Amarelle* cherries are pale red in colour and are less acid and considered more suitable for dessert. The other two possess fruits darker in colour and yield reddish juice (Zielinski, 138 ; Mansfeld, 139).

The sour cherry is believed to be a native of West Asian and South-East European regions. It is grown in Europe and America for its ornamental flowers. In India, it is said to be grown in Kashmir, Kumaun and Garhwal at elevations up to 2,300 m. No information is available regarding either the extent of cultivation of the sour cherry as distinct from the sweet cherry (*P. avium*, q.v.) or other aspects of its cultivation in this country. In general, the sour cherry is not as exacting in its climatic and soil requirements as the sweet cherry and is said to thrive even when neglected better than most other similar trees. In contrast to the sweet cherry, most of the sour cherry types are self-compatible but are said to set better crops when cross-pollinated ; the crop is said to be practically immune to San Jose scale and is comparatively more resistant to diseases and pests. The method of propagation and cultural practices are in general the same as in the case of sweet cherry (Chandler, 1957, 392–96 ; Bailey, 1947, I, 738–40 ; Bailey & Bailey, 169–70).

Utilization and Chemical Composition—The sour cherry is too acid for most tastes to be used as a table fruit, but large quantities are used for canning and cooking. Cherry juice is mostly obtained from sour cherries, for sweet cherries are ordinarily too valuable to be used for juice. The fruits of the sour cherry yield a clear red to reddish orange coloured aromatic juice, with a characteristic odour and a sour taste. Because of their acidity (malic acid content, >1%) and pleasant flavour, cherry juice and cherry syrup are used as popular vehicles for administering salty or bitter drugs and for masking iron preparations. Sour cherries are also used for the preparation of maraschino liqueur in Dalmatia. Information about processing and utilization of the sour cherry has been given under *P. avium* (q.v.) (Tressler & Joslyn, 701–06 ; Winton & Winton, II, 658 ; U.S.D., 1955, 272–73).

The chemical composition of sour cherry is similar to that of sweet cherry, except that the former has a much higher acidity. Analysis of the edible portion (88% of the fruit) of Indian red sour cherry gave : moisture, 83.4 ; protein, 1.1 ; fat, 0.5 ; minerals, 0.8 ; fibre, 0.4 ; and other carbohydrates, 13.8% ; calcium, 24 ; phosphorus, 25 ; iron, 1.3 ; potassium, 320 ; copper, 0.02 ; thiamine, 0.08 ; riboflavin, 0.08 ; nicotinic acid, 0.3 ; and ascorbic acid, 7.0 mg./100 g. ; vitamin A value, nil. Red sour cherries from U.S.A. are reported to contain 720 I.U./100 g. of vitamin A. The average acid content (as malic) of the juice of sour and sweet cherries has been recorded as 1.40 and 0.64 per cent, respectively. There is no marked difference in sugar content which is 10.3 and 11.4 per cent, respectively. *Morello* variety of sour cherry contains as high as 1.86 per cent acid (Nutritive Value of Indian Foods, 67, 103, 133 ; Watt & Merrill, *Agric. Handb., U.S. Dep. Agric.*, No. 8, 1950, 21 ; Winton & Winton, II, 666 ; Tressler & Joslyn, 702).

The pits of sour cherry, obtained in large quantities during canning, yield 28 per cent kernels containing 30–40 per cent of an edible oil. The pits

amount to 15–18 per cent of the fruit. The oil recovered from the kernels by cold expression is yellow in colour and of a mild pleasant flavour. The characteristics of the oil are given in Table 1 (p. 255). The fatty acid composition of the oil is as follows: myristic, 0.2; palmitic, 4.3; stearic, 2.9; arachidic, 0.8; oleic, 49.4; and linoleic, 42.4%. The cold-expressed oil resembles almond and apricot kernel oils in some respects, and is similarly employed in cosmetic and pharmaceutical preparations. It is also used as a salad or culinary oil. Hot-pressed oil is used in soap making (Jamieson, 173: Thorpe, III, 25; Eckey, 458–59).

The kernels contain a glucoside prunasine (*d*-mandelonitrile-*d*-glucoside; $C_{14}H_{17}O_6N$, m.p. 147–50°) belonging to the amygdalin group. The kernel press-cake on steam distillation yields 1 per cent of an essential oil similar to the oil of bitter almonds. The press-cake contains: protein, 30.9; crude fat (ether extr.), 13.1; N-free extr., 42.1; and crude fibre, 8.9%. The cake can be used as fertilizer, and after freeing from volatile hydrocyanic acid, as stock feed (Dictionary of Organic Compounds, V, 2803; Thorpe, III, 25; Cruess, 591).

The bark contains 5–7 per cent tannin and is said to be used for tanning purposes. The leaves contain amygdalin. The brown, semi-solid gum exuding from the bark resembles damson gum and is collected for use in medicine. On prolonged hydrolysis, the gum gives aldobiouronic acid which hydrolyses into various oligosaccharides (Wiesner, Lieferung 1, 281; Khan, *Pakist. J. For.*, 1956, **6**, 86; Chopra *et al.*, I, 363; Smith & Montgomery, 264–65).

The bark is bitter, and possesses febrifugal and antidiarrhoeal properties and is useful in allaying palpitation of the heart. An infusion of the leaves is reported to cure convulsions in children. The kernel, which contains a considerable proportion of hydrocyanic acid, is used as a nervine tonic. The fruit stalk is diuretic, astringent and pectoral. The gum of the tree is used as substitute for gum arabic. It is only partly soluble in water, darker in colour than gum arabic, more difficult to pulverize and inferior in adhesive properties. It is said to be used in many home remedies and to find application in pharmaceuticals and cough syrups (Kirt. & Basu, II, 957; Steinmetz, I, 119; Steinmetz, 1957, 909; *Chem. Abstr.*, 1962, **56**, 11716; Howes, 1949, 78; Mantell, 70).

The timber of the sour cherry is said to be used in Europe for the same purposes for which the timber of the sweet cherry is used.

P. ceylanica (Wight) Miq. syn. *Pygeum acuminatum* Colebr.; *P. gardneri* Hook. f.; *P. glaberrimum* Hook. f.; *P. wightianum* Blume ex C. Muell.; *P. zeylanicum* Gaertn.; *P. sisparense* Gamble

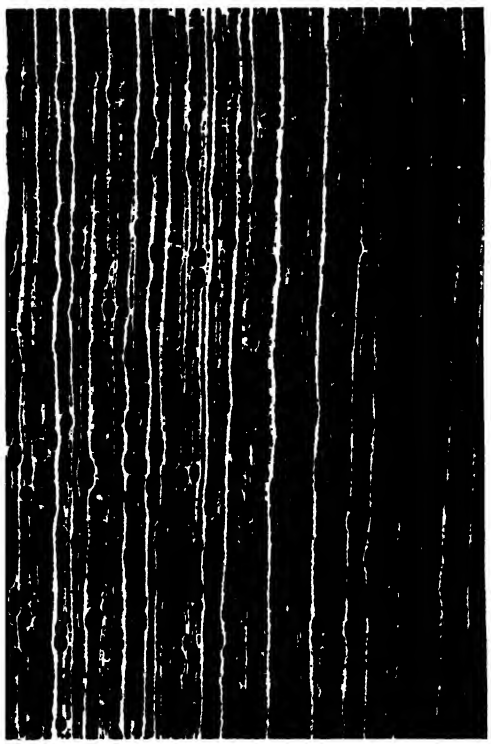
D.E.P., VI(1), 373; Fl. Br. Ind., II, 318–19, 321; Kalkman, *Blumea*, 1965–66, **13**, 52; Talbot, I, 504, Fig. 286.

Beng.—*Galmorre*; Mar.—*Daka*; Tam.—*Palan kacchi, atta-narei*; Kan.—*Sūgnigari*; Mal.—*Nai kambagam, rettiyan*.

Assam—*Gandhi gach*.

A medium to large sized tree up to about 25 m. in height, with smooth greyish bark, found in southern India, Deccan and Orissa and in the region eastward from Uttar Pradesh to Assam and in the Andamans. Twigs pubescent when very young; leaves oblong to ovate or ovate-lanceolate; flowers white or whitish in racemes; fruits ellipsoid to didymous, variable in dimensions, 9–18 mm. × 14–25 mm.

The plant is very variable in its taxonomical characters and had formerly been included under a number of species distributed in various areas. The



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 98—PRUNUS CEYLANICA—TRANSVERSE SECTION OF WOOD (×10)

wood (wt., 660–1,050 kg./cu.m.) which ranges from yellow to red in colour, is close-grained, moderately hard to hard, mottled and streaked. It is used for making crude furniture, boxes, planks, rafters and beams. It is a good fuel for burning bricks or lime (Gamble, 315; Krishnamurthi, 224; Worthington, 224).

Bark, leaves and fruits emit a strong smell of bitter almond when crushed. The bark is used in South Viet Nam for stomachache and also for making a beverage. The kernel, which smells of hydrocyanic acid, is used as fish-poison [Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(10), suppl., 161; Chopra, 1958, 588].

P. cornuta Steud. syn. *P. padus* Hook. f. (Fl. Br. Ind.) non Linn. HIMALAYAN BIRD CHERRY

D.E.P., VI(1), 348; C.P., 906; Rehder, 479; Fl. Br. Ind., II, 315.

KASHMIR—*Zambchule*; PUNJAB—*Bart, dudla, jamun, kalakat, paras*; UTTAR PRADESH—*Jamoi, jamunoi.*

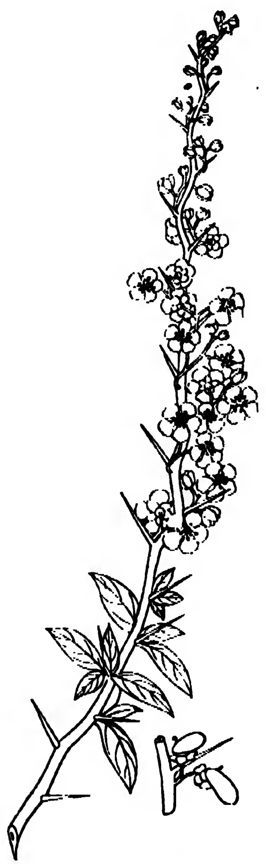
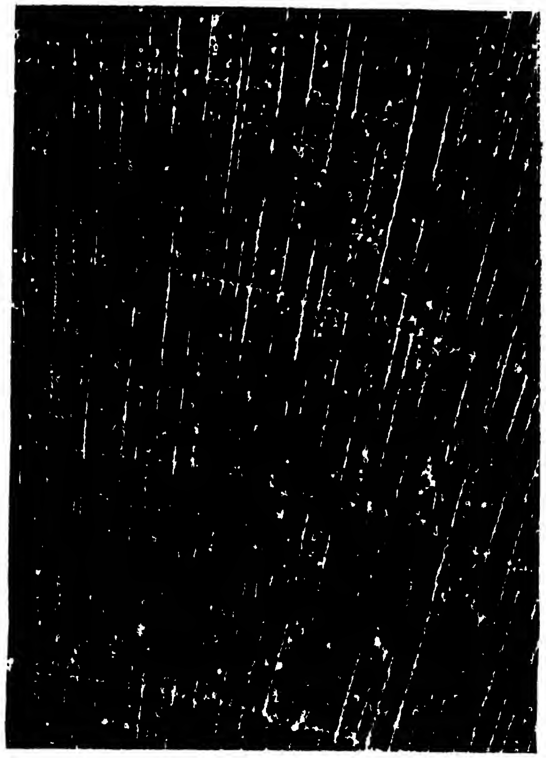


FIG. 99—PRUNUS CORNUTA—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 100—PRUNUS CORNUTA—TRANSVERSE SECTION OF WOOD (×10)

A moderate-sized or large tree up to 18 m. in height, distributed in the temperate Himalayas from Punjab to Assam at altitudes of 1,200–3,600 m. Bark brown, scaly; leaves variable, usually oblong-lanceolate with a cordate base, serrulate; flowers in long dense drooping racemes, white; fruit of the size of a large pea, red turning to dark purple or black, acrid, globose, sometimes developing a horn-like outgrowth caused by insect attack.

This species is closely related to *P. padus* Linn. (EUROPEAN BIRD CHERRY) under which it has been included by many authors. It occurs often gregariously on rather moist pasture grounds and in forest glades. It is a moderate light demander, coppices well and regenerates by root suckers freely (Troup, II, 488).

The wood (wt., 657 kg./cu.m.) is soft, fairly strong, durable and not attacked by insects. The sapwood is whitish and lustrous and the heartwood light reddish brown and dull with an unpleasant smell when first exposed. The timber is easy to saw, both in the green and dry state. It is suitable for turnery work and for rifle half-wroughts and for making different parts of racquets and also bobbins and boot lasts, but

supplies of the timber are limited. It also furnishes a useful firewood (Pearson & Brown, I, 476; Trotter, 1944, 223, 227; Gamble, 314; Ishaq, *Pakist. J. For.*, 1957, **7**, 20).

The tree yields an inferior gum in small quantities. The fruit which is mawkish and astringent is eaten and can be used for brewing liquors. An oil expressed from the kernels is said to be a good substitute for oil of bitter almonds. The leaves afford an excellent fodder for cattle.

P. domestica Linn. syn. *P. communis* Huds.
COMMON PLUM

D.E.P., VI(1), 347; Fl. Br. Ind., II, 315; Bailey, 1947, III, 2715, 2826, Fig. 3068–72.

HINDI, BENG. & GUJ.—**Alubukhara, alucha.*

A small tree, with twigs pubescent when young; flowers white, usually in clusters; fruits firm in texture, varying in colour from green and golden yellow to red and dark purple; stones large, rough or pitted.

Of all the stone fruits, plums are the most varied and include a large range of types varying in plant habit, leaf size and form, flowering habit and fruit characteristics and quality. Consequently they have been variously classified, sometimes into distinct species, sub-species or varieties. Based on their original geographical origin, they are broadly grouped as Eurasian, Oriental or Japanese and North American, each group comprising two or more species, besides sub-species and varieties. As far as Indian material is concerned, they are mostly Eurasian or Oriental in origin and belong to either *P. domestica* or *P. salicina*; a few of the Eurasian types belong to *P. cerasifera* (Myrobalan Plum) and have already been dealt with under that specific name.

Best known among the cultivated plums are types belonging to *P. domestica,* including those grouped under *P. insititia* Linn., which is considered by many either as a sub-species or as a variety of *P. domestica.* Types belonging to sub-species *insititia* Bailey are somewhat more dwarf and compact in habit than those belonging to sub-species *domestica,* and their flowers are smaller and less pubescent and fruits lesser in diameter and usually more nearly round; their stones are also smaller and often adherent to the flesh than in sub-species *domestica.* Types belonging to sub-species *insititia* are however, hardy, vigorous and productive and are adapted to a wide range of conditions (Zielinski, 141; Rehder, 456; Mansfeld, 136).

P. domestica subsp. *domestica* is thought to be a native of the Caucasus and trans-Caucasus regions and subsp. *insititia,* a native of western Asia and south-eastern Europe. Some authors consider them to have originated in nature as allotetraploid hybrid of *P. cerasifera* ($2n=16$) a diploid species, with *P. spinosa* Linn. ($2n=32$) a tetraploid species, followed by chromosome duplication, to give rise to the fertile hexaploid *P. domestica* ($2n=48$). The subsp. *insititia,* which is also a hexaploid is said to be somewhat intermediate in character between *P. domestica* and *P. spinosa* and is thought to be a stage in the reversion of *P. domestica* towards wild or semi-wild forms. The occurrence of natural hybrids closely resembling the common plum in areas of North Caucasus, where both *P. cerasifera* and *P. spinosa* grow, and the synthesis of fertile hybrids resembling the plum by hybridization of these two species are said to support this view (Bailey, 1947, III, 2826; Chandler, 1957,

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FIG. 101—PRUNUS DOMESTICA—IN FRUIT

* The plum known in India as *Alubukhara* is considered by some to belong to *P. salicina*; some others, however, are of the opinion that it deserves a separate specific rank. It has been designated as *P. bokhariensis* (Royle) Schneid. and considered indigenous to Kashmir (Naik, 330 33; Ginai, *Agric. Pakist.*, 1953, **4**, 167; Schneider, *Repert. Spec. Nov. Regni Veget.*, 1905, **1**, 51).

341; Zielinski, 150; Crane & Lawrence, 237; Garnaud, II, 57; Zhukovsky, *Euphytica*, 1965, **14**, 177).

The plums are cultivated largely in Europe where they are said to rank first among tree fruits, and to a lesser extent in America; they are said to lack to a great extent the power of adaptation to trans-Atlantic conditions. In India, they are not of much commercial importance. The area under the plums in Himachal Pradesh is about 750 hectares (including both *P. domestica* and *P. salicina* types) and a recent census has revealed that there are about 3,000 trees of plums growing in a semi-wild state in the Chini area of that State. The plums cultivated in the Nilgiris in South India (60–80 ha.) are reported to belong to *P. salicina; P. domestica* does not thrive well there except for the type *Splendour,* suitable for drying into prune, and for *Alubukhara* reported good for stewing. Both *P. domestica* and *P. salicina* do well in northern India. Some of the *P. domestica* types under commercial cultivation are: *Damson, Maynard, Green Gage, Grand Duke,* and *Victoria.* Besides these, a large number of other types are reported under trial in Mashobra in Himachal Pradesh and Chaubattia in Uttar Pradesh. Scope for extending the area under the plums is said to be quite good as the tree comes to bearing quite early and bears heavily year after year. Another consideration is the fact that certain types of the common plum can be grown in sub-montane tracts as fillers in mango groves. Though the quality of the fruit produced in these latter areas may not be very good, the fruits ripen early and command a good price and are also suitable for jam making and canning purposes [Thapar, 102; Chadha, *Himachal Hort.*, 1960, **1**, 63; Srivastava & Sharma, *Gardening*, 1963, **4**(11), 1; Mukherjee & Singh, *Indian Hort.*, 1963–64, **8**(3), 21].

The various types of common plum can be divided into three classes, depending upon their degree of pollen self-compatibility. In the first class are those that are completely self-incompatible. The second class comprises types which are only partially self-compatible and are not capable of producing a satisfactory crop with their own pollen. All the remaining types are completely self-compatible. In the first two classes are also found a few types which in addition to being self-incompatible are also cross-incompatible to a lesser or greater extent (Crane & Lawrence, 196–97; Chandler, 1957, 343).

The diploid chromosome number of *P. domestica* is 48. The two sub-species *domestica* and *insititia* are completely interfertile. Interspecific crosses with other species of *Prunus* have, however, proved unsuccessful, fruits with viable seeds being but rarely formed. The hybrids so raised have the expected intermediate chromosome numbers and are highly sterile. The inheritance of some economically important characters of the common plum such as colour, shape and size, flavour of the fruit and habit of growth has been studied (Crane & Lawrence, 212).

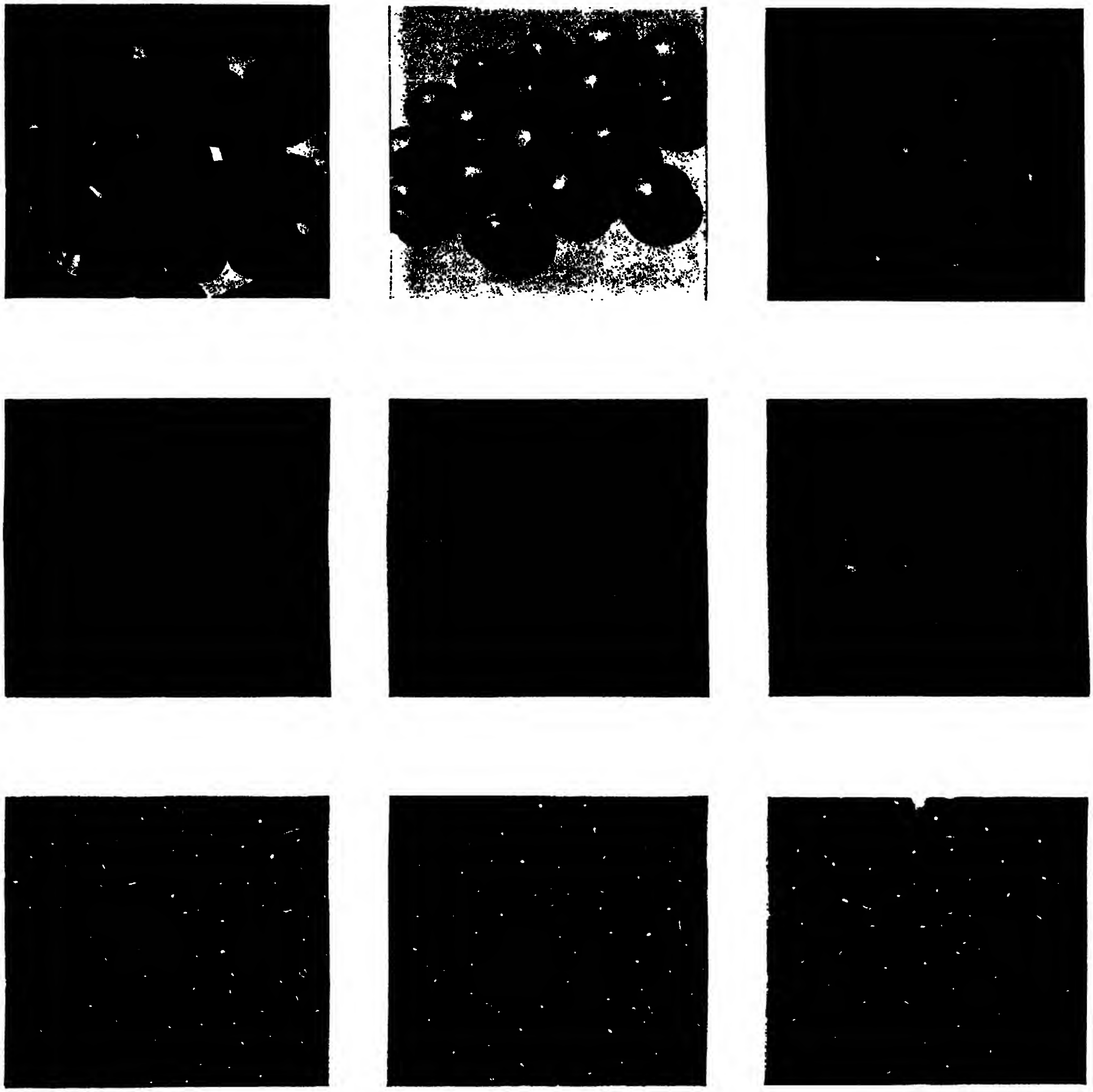
Cultivation

Climate and Soil—The plum is said to require warmer situations than the apple and pear and is best suited to hilly areas at elevations of 850 to 1,450 m. It requires a deep, fertile and well drained loamy soil, but adaptation to diverse soil types is said to be possible by the use of suitable stocks (Thapar, 102; Bailey & Bailey, 575; Singh *et al.*, *Punjab hort. J.*, 1962, **2**, 129).

Propagation—Propagation is done by budding or sometimes grafting on many kinds of seedling stock. Peach, plum and apricot stocks are used in this country, while in U.S.A. the myrobalan plum stock is widely used. The plants are set down at a distance of 4.5–8.0 m. each way, depending on the growth habit of the type planted. Stem cuttings of certain types of plum treated with hormone preparations like indole acetic acid and β-indolyl butyric acid are said to have been successfully used for propagation. As in the case of almond, the types of plums which are to be planted in an orchard should be interfertile and have overlapping blooming periods [Thapar, 102; Crane & Bradley, *Calif. Agric.*, 1956, **10**(10), 5; Bailey, 1947, III, 2716; Chandler, 1957, 346, 343; Dikshit, *Sci. & Cult.*, 1956–57, **22**, 391; Teaotia, *Gardening*, 1956–59, **1**(1), 11; Varma, *Punjab Fr. J.*, 1945, **9**, 134].

Irrigation is required in the summer months, particularly in the submontane areas. The trees have to be well manured with farmyard manure as well as inorganic fertilizers [Thapar, 103; Rajendra Singh, *Himachal Hort.*, 1961, **2**(3), 79].

Pruning—The various types of plums have different growth habits and they have to be pruned differently. Those that have an upright habit should be trained and pruned on the modified leader system, while those with spreading habit are pruned on the vase-form system. Pruning in established trees consists of mere removal of crowding and crossing branches. Pruning should be regulated to enable trees to make 30–50 cm. of new growth each year. The



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PRUNUS—FRUITS OF DIFFERENT SPECIES

1, 2, 3, Plums (P. domestica); 4, Apricot (P. armeniaca); 5, 6, Peaches (P. persica); 7, 8, 9, Cherries (P. avium)

fruits are borne mostly on the spurs, which should not be removed unless it is desired to thin the fruit. Fruit set in the plum is often excessive particularly in the Japanese types and thinning is necessary. This is done after the natural fruit drop in April and May, but before the pit hardens [Thapar, 103; Sham Singh *et al.*, 339; Balbir Singh, *Indian Hort.*, 1962–63, **7**(2), 16].

Diseases and Pests—The plum is subject to very few diseases and pests in India. Bacterial gummosis or canker caused by *Pseudomonas* sp. is sometimes fairly serious and the affected part is scraped out and treated with Bordeaux mixture. The plum is also subject to some types of virus diseases like line pattern and mosaic affecting the leaves (Thapar, 105; Nagaich & Vashisht, *Indian J. agric. Sci.*, 1965, **35**, 157).

The plum lecanid, *Eulecanium* (*Lecanium*) *coryli* Linn. (*L. capreae* Linn.) attacks the stem and branches from which it sucks juice. It is recorded from Kashmir, but is said to be spreading and assuming an epidemic form. The weevil, *Amblyrrhinus poricollis* Boheman, feeds on tender leaves, the damage being sometimes severe in young plantations. The beetle, *Anomala lineatopennis* Blanchard, visits the host at night and feeds on leaves and fruits. Several other beetles also attack the plum and bring about complete defoliation. Lead arsenate and DDT wettable spray are said to give effective control. The gregarious hairy caterpillars of *Euproctis fraterna* Moore defoliate the trees and also feed on the young fruit and bark (Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 88, 91, 93; Trehan, *J. Bombay nat. Hist. Soc.*, 1956–57, **54**, 581).

Harvesting and Yield—The various types of plum come to harvest during the months of July and August. The fruits are harvested when they have developed good colour, but are still firm enough to withstand transport to distant markets. They can be picked at a later stage of ripening for the local market or for canning and jam making. The plum tree starts bearing in 3–4 years from planting and continues to bear profitable crops for about 25 years. The average yield per tree in India is said to be about 40 kg., though yields of nearly 110–150 kg. per tree have been recorded in areas of Himachal Pradesh in some prolific types. The average yield in several areas of U.S.A. is said to be 100–150 kg. and instances of trees yielding 300–400 and even 550 kg. are said to be on record (Thapar, 105; Bailey, 1947, III, 2721).

In some areas of Himachal Pradesh, the bigger growers auction or sell the standing crop to contractors while the smaller growers do the harvesting themselves and take the produce to market to sell to wholesalers. Sometimes the contractors buy fruits from small growers by weight at agreed prices. Plums grown in hills and picked when fully mature but still hard and firm can be ripened in the plains. The fruit develop characteristic colour and flavour, and softening of flesh when stored at 0–2° and 85–90 per cent R.H. for 4–8 weeks (Kirpal Singh, *Himachal Hort.*, 1961–62, **2** & **3**, 200).

The fruit is graded in some areas into five grades by size. The better grades are packed in wooden boxes of 9 kg. capacity for transport and the rest in bamboo baskets of the same or double the capacity. Marketing is done through commission agents [Rajendra Singh, *Himachal Hort.*, 1961, **2**(3), 79].

UTILIZATION AND CHEMICAL COMPOSITION

Plums are used as dessert; they are cooked and eaten, canned and dried, and also made into jams. Small quantities are processed in Uttar Pradesh (Table 3). Certain types of plums are dried successfully without the removal of the pit and are distinguished as PRUNES. For this purpose, types containing a large proportion of solids, particularly sugars are preferred; the type *Splendour* grown successfully in Coonoor (Nilgiris) is said to be very suitable. In the Pacific coast area of America and in some areas of central and southern Europe, large quantities of the fruit are dried and made into prunes. For this, the fruits are allowed to ripen thoroughly on the tree and fall to the ground. They are gathered and immersed for a few seconds to nearly a minute in a hot lye solution to remove wax and then passed over a needle board so as to slightly cut the skin, and then placed on trays and dried in the sun or by artificial heat. Under normal weather conditions drying in the sun takes 10–15 days to be completed. The dried product is then glossed, or treated to give a glossy appearance to the skin and also to sterilize it. Fresh fruits weighing 1.0–1.5 kg. give 0.5 kg. of the dried product (Hill, 396; Chandler, 1957, 345; Shoemaker & Teskey, 367–70; Cruess, 436–40; Naik, 340).

Prunes are demulcent, mildly laxative and refrigerant and often added to cathartic decoctions to improve their flavour and promote their effect. Prunes are canned and used for the preparation of prune pulp and prune beverage. Prune pulp free from pits is prepared by steaming prunes to softness and

passing them through a pulper. The pulp finds some use in ice-cream mix, in fountain drinks, in bread making, candy, jelly, breakfast cereals, custards, fancy pastries and meat sauces. Pitted prunes are excellent for fruit cakes, plum pudding and pies, and can be used as a substitute for raisins. Prune juice may be prepared either by extracting the prunes with hot water or heating them with water under slight pressure in a cooker. The juice is concentrated and pasteurized. It contains 12 per cent of reducing sugars. *Alubukhara* gives a fairly good canned product and the juice of *alucha* can be made into a squash (Merck Index, 868; Cruess, 529; B.P.C., 1959, 630; Wren, 284; von Loesecke, 1942, 97–101, 471; Girdhari Lal *et al.*, 70, 127; Siddappa & Ranganna, *Food Sci.*, 1961, **10,** 29).

Plums contain appreciable amounts of sugars and carotene (vitamin A). Analysis of the edible portion (90–93% of the fruit) of the red plums from Punjab, gave the following values: moisture, 86.3; protein 0.7; fat, 0.4; fibre, 0.4; other carbohydrates, 11.7 and minerals, 0.5%; calcium, 10; phosphorus, 20 iron, 1.4; potassium, 190; copper, 0.05; nicotinic acid, 0.1; and ascorbic acid, 0 mg./100 g.; vitamin A value, 166 I.U./100 g. Small plums (*alucha*) contained 983 I.U. of vitamin A/100 g. The ripening of the plum is characterized by softening of the flesh, development of pigment, marked increase in sugars and relatively smaller decrease in acid content. The enzymes polyphenolase and peroxidase are involved in the browning process of prunes. Average composition of pitted fruits of the typical plum *Maynard* grown in Chaubattia (Almora) gave: moisture, 83.0; sol. solids (mostly sugars), 11.2; and total acids (as malic), 1.74%; ascorbic acid, 5.0 mg./100 g. Some types are highly acidic. The acidity is due to citric acid, although small proportions of tartaric and malic acids have been reported. Sugars present are glucose (3.0–6.2%), fructose (2.7–6.1%) and sucrose (0.7–4.8%); some observers have recorded sucrose as a minor component. The average pectin content (as calcium pectate) ranged from 0.8 to 1.3 per cent (Nutritive Value of Indian Foods, 73, 108, 136–37; Shah, *Sci. & Cult.*, 1965, **31,** 631; Winton & Winton, II, 640–42; Thorpe, X, 121; Money & Christian, *J. Sci. Fd Agric.*, 1950, **1,** 8; *Chem. Abstr.*, 1954, **48,** 7707).

Prunes are particularly rich in sugars and have usually lower acidity than plums. The edible portion (85% of the fruit) of partially dried prunes contains: moisture, 35.3; protein, 0.3; fat, 0.3; fibre, 2.0; other carbohydrates, 60.4; and minerals, 1.7%; calcium, 80; phosphorus, 40; iron, 4.8; thiamine, 0.5; nicotinic acid, 1.6; and ascorbic acid, 2.0 mg.; and vitamin A value, 317 I.U./100 g. Sugar and acid contents recorded for dried prunes from U.S.A. are: sucrose, 3.4; invert sugars, 43.9; and total acid (as citric), 1.2% (Nutritive Value of Indian Foods, 73, 107, 137; Winton & Winton, II, 639, 642).

Plum pits (2.3–6.0% of the fruit) yield up to 26.7 per cent of kernels which are bitter and contain: water, 9.6; protein, 20.2; fat, 39.5; lecithin, 0.15; carbohydrates, 15.0; fibre, 12.2; ash, 3.4; and hydrocyanic acid (free), 0.06%. The kernels also contain amygdalin and phosphatides (0.3% in the seed) (Winton & Winton, I, 491, 493; *Chem. Abstr.*, 1949, **43,** 3538; Wittcoff, 235).

Plum kernels yield about 39–42 per cent of a fatty oil which resembles expressed almond oil and can be used for the same general purposes. On extraction with petroleum ether, *Alubukhara* kernels (20% of the pits) gave 39.1 per cent of a light yellow non-bitter oil with a pleasant odour and taste. The characteristics of the oil are given in Table 1 (p. 255). The fatty acid composition of the oil is: lauric, 0.9; myristic, 3.8; palmitic, 0.6; stearic, 4.2; arachidic, 5.5; oleic, 65.2; and linoleic, 19.8%. Plum kernel oil possesses good keeping qualities and can be used as a substitute for almond oil. It is suitable for lubricating finer machinery after admixing with light mineral lubricating oil. The oil is extracted in the plum-growing hilly areas in India to a limited extent and used for lubricating, cooking and hair dressing purposes and as illuminant. *Alubukhara* seeds which are available in large quantities on the hills and at present hardly find any commercial outlet, can be profitably utilized as a source of this oil. The coarse meal obtained after the extraction of oil is considered as nutritious as cottonseed meal. The oil-free cake contains: protein, 37.5; crude fibre, 2.4; carbohydrates, 40.9; and ash, 5.3%. An essential oil similar to the oil of bitter almonds can be distilled from the cake; the oil yield is reported to be 0.4 per cent of the kernels (Eckey, 459; Dhingra & Dhingra, *Indian Soap J.*, 1952–53, **18,** 187; *Chem. Abstr.*, 1949, **43,** 3538; Guenther, V, 49).

The aroma of plum blossoms is mainly due to benzaldehyde. The polysaccharide moiety of the gum present on the fruit surface is composed of D-galactose, D-mannose, L-arabinose, D-xylose, L-rhamnose, glucuronic acid and probably traces of 4-*o*-methylglucuronic acid. The heartwood contains the flavonoid, kaempferol, dihydrokaempferol, kaemp-

feride, dihydrokaempferide, and prudomestin, besides a leucoanthocyanidin (*Chem. Abstr.*, 1955, **49**, 6877; 1960, **54**, 5831; Nagarajan & Seshadri, *J. sci. industr. Res.*, 1961, **20B**, 509; *Phytochemistry*, 1964, **3**, 477; *Curr. Sci.*, 1966, **35**, 409).

The bark contains tannin (6.8%). The brownish semi-solid gum exuding from the bark (the Damson gum from *insititia* plums) resembles gum arabic in appearance and properties. It has a constitution similar to that of the fruit gum but contains higher proportions of D-mannose, L-arabinose, and hexuronic acid. The gum is said to be used sometimes as an adulterant of arabic, ghatti and tragacanth and in confectionery (Alauddin & Ahmed, *Proc. 5th Pakist. Sci. Conf.*, 1953, pt III, 120; Smith & Montgomery, 259-60, 289; Mantell, 71; *Chem. Abstr.*, 1960, **54**, 5831).

The wood of *P. domestica* is reddish brown, hard, very close grained and weighs 835–65 kg./cu.m. It is capable of very smooth surface from the tool and is used in Kashmir for the skeleton of papier mache boxes. For cabinet-work, inlay and turning, it is said to be very suitable (Gamble, 314; Howard, 488).

Trade. Small quantities of plums, fresh as well as preserved are exported but sizeable quantities of fresh plums and smaller quantities of dried plums and prunes are imported every year, West Pakistan and Afghanistan being the main suppliers (Tables 4 and 5, p. 261).

P. laurocerasus Linn. syn. *Laurocerasus officinalis* M. Roem. CHERRY LAUREL

Rehder, 480; Bailey, 1949, 545.

A shrub or small tree, up to 6 m. high, with handsome evergreen foliage: leaves glossy, ovate, lanceolate or oblanceolate, serrate usually above the middle; flowers small, white, in axillary or terminal short racemes: fruit small, globose, dark brownish purple or black.

It is a native of Asia Minor and South-East Europe and is cultivated widely as an ornamental. It has been introduced into the Nilgiris, where fruiting has not been observed so far (Information from the Curator, Govt. Bot. Gardens, Ootacamund).

Fresh leaves give an odour like that of bitter almond when crushed. When macerated in water and distilled, they yield Cherry Laurel Water which is standardized to contain 0.1 per cent hydrocyanic acid. This is used as a sedative in symptomatic treatment of nausea and vomiting as an antispasmodic, as an ingredient of eye lotions and as a flavour. An essential oil known as Oil of Cherry Laurel, can be obtained by redistilling the distillation water (yield 0.05% from leaves). It is similar to the oil of bitter almonds in physico-chemical properties but differs in odour. The characteristics of the oil are: sp. gr.$^{15°}$, 1.044–1.067; $[\alpha]$, mostly inactive, occasionally up to $-0.2°$; $n^{20°}$, 1.5417–1.5440; aldehyde (as benzaldehyde), 82.7–91.2%; hydrocyanic acid, 1.4–2.8%; solubility, 2.5–3 vol. of 60 per cent alcohol. The oil contains also *d*-mandelonitrile and probably benzyl alcohol. The leaves contain the glucosides prulaurasine (*dl*-mandelonitrile β-D-glucoside) and prunasine (*d*-mandelonitrile-*d*-glucoside) which on hydrolysis with emulsin present in the leaves, yield the essential oil (U.S.D., 1955, 1733; Wallis, 126; Guenther, V, 55; B.P.C., 1949, 470; Allen, III, 411; Dictionary of Organic Compounds, V, 2803).

The crushed fresh leaves are said to be used in preparing the killing bottle by entomologists for collection of insects. The leaves are not palatable to cattle, but when they are eaten by cattle, the results are reported to be fatal (Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 40; Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 52).

The seeds contain 25–30 per cent of a fatty oil, and 0.034 per cent of hydrocyanic acid. The component acids of the oil (iod. val., 110) are: palmitic, 9.9; stearic, 1.7; myristic, 1.8; oleic, 73.4; and linoleic, 13.2% (Thorpe, IX, 22; *Chem. Abstr.*, 1962, **57**, 2330; Hilditch, 1956, 195).

P. mahaleb Linn. MAHALEB CHERRY

D.E.P., VI(1), 348; Fl. Br. Ind., II, 312; Bailey, 1949, 544.

A small tree, up to 10 m. high, indigenous to central and southern Europe and western Asia. Leaves ovate crenate; flowers small, fragrant, in short racemes; fruits small, about 6 mm. in diam., black, on long pedicels.

This tree is sometimes preferred to *P. avium* as a stock on which to bud sweet and sour cherries. It is said to tend to dwarf the sweet cherry tree and be overgrown by it. Mahaleb seedlings are reported to be highly variable in form and growth. A number of horticultural types are grown as ornamentals. It is usually propagated through seedlings, but propagation can also be done through root cuttings (Rehder, 475; Zielinski, 133; Chandler, 1957, 381–90).

The fruits are hard and too bitter to be edible but can be used for making pies. The kernels contain amygdalin and are said to be sold in Indian bazaars

for use in indigenous medicine as a substitute for hydrocyanic acid. They are used also in the liquor industry and perfumery. The kernels yield 35–36 per cent of a drying oil of golden yellow colour and pleasant odour. The oil has characteristics different from oils of almond, apricot, peach, plum and cherry. A sample of cold extracted oil showed: $d_{4°}^{25°}$, 0.9282 $n_D^{25°}$, 1.4976; viscosity at 20°, 1.45 and at 25°, 1.12 p. iod. val. (Kaufmann), 146.7; thiocyanogen val., 88.7 and unsapon. matter, 0.52%: constituent fatty acids: *α*-eleostearic, 38.7; linoleic, 18.4; and oleic, 41.3%. The oil may be useful as a drying oil in lacquers (Marshall, 36; Kirt. & Basu, II, 963; Steinmetz, II, 363; Wehmer, I, 479; *Chem. Abstr.*, 1955, **49**, 9294; Eckey, 460).

The odoriferous leaves are used in the manufacture of perfumes and in cooking to give savour to sauces. They contain quercetin, kaempferol, and probably *p*-coumaric and ferulic acids. The leaves and stems are reported to possess insecticidal properties. The bark yields prunitroside, prunetin, 7-methoxycoumarin and a bitter glycoside mahaleboside ($C_{15}H_{16}O_8$, m.p. 268°). Flavonic compounds, aromadendrine, naringenine, prunetine, and genisteine have been isolated from the heartwood (Marshall, 36; Bate-Smith, *J. Linn. Soc., Bot.*, 1961–64, **58**, 39; *Chem. Abstr.*, 1960, **54**, 16547; *For. Abstr.*, 1960, **21**, 123).

The wood is favoured for cabinet-making and for the manufacture of pipe-stems (Marshall, 36).

P. napaulensis Steud. syn. *Padus napaulensis* Schneid.
Fl. Br. Ind., II, 316; Fl. Assam, II, 178.

N.E.F.A. & N. Bengal *Aroopaty*; Assam—*Saiong*.

A moderate-sized to a fairly large tree, about 17 m. in height, found in temperate Himalayan regions at altitudes of 1,200–3,000 m. from Kumaun to Sikkim and in N.E.F.A., Khasi hills and Manipur. Bark dark brown, grey or greyish white, somewhat rough; leaves 7.5–15.0 cm. × 3–6 cm., lanceolate, crenate-serrate; flowers white, in racemes; fruits fleshy, 1.75 to 2.0 cm. long, black, globose, acid or subacid.

It is closely related to *P. cornuta* and resembles *P. cerasoides* very much but can be distinguished by the fruits which are more than twice as large. It is said to be often cultivated in Assam for its fruits. It is very frost hardy and so is a useful species for planting for fuel in tea plantations at higher elevations. It can be sown in lines 1.75 m. apart or raised in nursery under shade for later transplantation (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 146).

The wood has a large white sapwood and red brown heartwood, with numerous medullary rays and a pretty grain. It is said to polish well and is used for planks in N.E.F.A. The leaves are said to be fatal when eaten by cattle [Cowan & Cowan, 59; Srinivasan, *Rec. bot. Surv. India*, 1959, **17**(2), 19].

The bark of *P. napaulensis* yields triterpenes, friedelin ($C_{30}H_{50}O$, m.p. 252–56°) and epifriedelinol ($C_{30}H_{52}O$, m.p. 273–76°) (Barua & Maiti, *Sci. & Cult.*, 1957–58, **23**, 155).

P. persica Batsch Peach, Nectarine
D.E.P., VI(1), 349; Fl. Br. Ind., II, 40; Rehder, 463.
Hindi *Aru, shaftalu*.

A small tree up to 8 m. high, with glabrous twigs; leaves oblong to broad lanceolate, serrate, glabrous; flowers solitary, pink; fruits subglobose, 5–7 cm. across, fleshy, with a hard and deeply pitted stone.

This species is broadly divided into three varieties, var. *persica* (Common Peach), var. *nectarina* (Ait.) Maxim. (Nectarine) and var. *compressa* Bean (Flat Peach). These are again subdivided into two groups based on the nature of the flesh, i.e. whether it is adherent to the stone (Clingstone) or free from it (Freestone) (Rehder, 463; Mansfeld, 139).

The peach is believed to be a native of China where a related species, *P. davidiana* Franch. is found growing wild even today. It is considered to have been introduced to the west by way of Persia which, for some time, was believed to be the country of origin. The nectarine is identical with the peach in tree and flower characteristics, but differs from it only in the absence of fuzz or pubescence on the fruit. It is believed to have arisen from the peach by seed and bud variation. Nectarines may spring from peach seeds and peaches from nectarines (Vavilov, 26; Zielinski, 160–61; Cullinan, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 673).

Peaches are grown in most parts of the temperate zones; the major producer is U.S.A., where the peach ranks second to the apple in importance. Other important producers are: Italy, France and Spain in Europe, China and Japan in Asia, Argentina in South America, Australia and South Africa. In India, peaches are grown in Kashmir, Himachal Pradesh, sub-montane tracts of Punjab, Uttar Pradesh, and to a limited extent in the Nilgiris. According to available data, about 400 hectares are said to be cultivated in Kashmir, Kulu Valley, Himachal Pradesh and

Kumaun hills, mostly under improved types introduced from other countries. Inferior types of peach are also grown over about 800 hectares in the sub-montane regions of Punjab and Uttar Pradesh. The cultivation of the peach appears to be expanding in some of these areas, the area in Himachal Pradesh alone being estimated at more than 550 hectares in 1965–66, in addition to about 30,000 wild peach trees occurring in the Kinnaur area of that State [Zielinski, 160; Thapar, 105; Singh, *Farm Bull.*, No. 19, 1957; Srivastava & Sharma, *Gardening*, 1963, **4**(11), 1; Singh & Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1956, **6**(8), 17; Information from Director of Agriculture, Himachal Pradesh].

Varieties—In its long history of domestication and migration the peach is said to have taken innumerable forms, some of which are quite extreme. A certain peach from China has fruits each weighing as much as 0.45 kg. and possessing remarkable shipping qualities. Another type, *Sharbati*, which is Indian, is said to yield a prolific crop under conditions existing in the plains of northern India, the fruits being of good quality. *Red Ceylon*, a type introduced into U.S.A. from Ceylon is considered a tropical peach, as it has an extremely low-chilling requirement for flower induction and is said to be successfully cultivated in South and Central Florida. There is also a type which can withstand a continuous temperature of 32° during its period of ripening, and another which can stand atmospheric storage over five months; a type from South Africa is said to thrive even on very rocky ground. A dwarf type from China begins to bear when only 35 cm. in height [Zielinski, 158–63; Ledin, *Econ. Bot.*, 1957, **11**, 368; Sturrock, 148; Mukherjee & Singh, *Indian Hort.*, 1963–64, **8**(3), 21; Tao Jungtsung, *Indian J. Hort.*, 1956, **13**, 58].

Many attempts have been made to devise a natural classification of the many hundreds of types (*c.* 3,000 in U.S.A. alone) of the cultivated peach, but the large number of new types which continue to be produced, as well as the variation occurring when types are grown under different conditions, are said to make this task virtually impossible. An arbitrary system has been suggested based upon the presence or absence of pubescence, clingstone or freestone, colour of flesh, shape of fruit, time of maturity, and lastly the processing quality of the fruit, viz. suitability for canning, freezing or dessert use (Zielinski, 158–63; Cullinan, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 673).

The chromosome number of the peach is 2n=16. The peach has been hybridized with the plum and almond. Though the hybrids are sterile, some are said to show promise as rootstock to the peach. Most of the commercially important types of peach are self-fertile, but a few types are said to be self-incompatible because of pollen sterility. Extensive breeding work is in progress to evolve new types able to meet various requirements such as resistance to cold, low winter chilling requirements, desirable processing qualities and higher fruit quality with regard to size, firmness, flavour and appearance (Zielinski, 163; Garnaud, II, 74; Cullinan, loc. cit.; Crane & Lawrence, 125).

Among the important types grown in India are: *Alexander, Peregrine, Early Rivers, Duke of York, Babcock, Elberta, Honey, J. H. Hale*, and *C. O. Smith* introduced in the growing regions in northern India. *Halberta Giant*, a cross between *J. H. Hale* and *Elberta*, is being tried in Himachal Pradesh: it has very large attractive fruits, with firm juicy sweet pulp and like *Elberta* is considered to be a good canning type. *Totapari* is said to be a very good canning peach extensively grown in the Ramgarh area of Naini Tal district (Uttar Pradesh). *Killikarankie* and *Shanghai Seedling* are the two types which are found to be successful in the Nilgiris (Thapar, 108; Naik, 345; Information from Directorate of Fruit Utilization, Uttar Pradesh).

Cultivation

Climate and Soil Of all the temperate fruits the peach has the least chilling requirements and it is grown to a limited extent in the plains as well as in the sub-montane areas and in the hills. But peach types of high quality and exquisite taste thrive well in mild hilly areas. In the plains, the peach does not thrive because of the hot scorching winds prevalent in summer. In the Himalayan region, elevations of 850–1,700 m. are most suitable for its cultivation. In the Nilgiris, it is being grown at elevations of 1,300–1,750 m. A breeding programme has been initiated in India to evolve superior types that can thrive under sub-tropical conditions. While the tree can thrive and produce profitable crops on a great range of soil types, the best soils are, however, well drained, light sandy, gravelly or rocky loams, which are fairly fertile. The soil nitrogen requirement of the peach tree is said to be higher than that of other temperate fruits, excepting the almond (Dewan, *Punjab hort. J.*, 1962, **2**, 96; Chandler, 1957, 379–80; Thapar, 106; Hayes, 436–37;

Krishnamurthi, 118; Randhawa *et al., Indian J. agric. Sci.*, 1963, **33**, 129; Shoemaker & Teskey, 189; Talbert, 81–82).

Propagation—The peach is usually propagated in India by ring budding or shield budding on seedling peach stock. For raising seedlings, seeds extracted from fresh fruit and washed well give best results, as otherwise they lose their viability. Properly dried and cured seeds may be kept for 4 years or more in cold storage. Peach seeds take a long time to germinate; it may be necessary sometimes to carefully crack open the shell and plant the kernel in order to obtain quicker germination. Twenty-month old seedlings are reported to have given best results as stock in the Nilgiris. Plum stock has been tried but is said to have proved uncongenial. The peach thrives well when budded on bitter almond stock or on apricot seedlings. Apricot rootstock has been used sometimes in U.S.A. to prevent root knot nematode infestation: several peach types have also been tried successfully for this purpose and *Shalil*, a type introduced from India, is said to be one amongst them [Thapar, 106; Singh & Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1956, **6**(8), 6; Cochran *et al., Yearb. Agric., U.S. Dep. Agric.*, 1961, 233; Mustafa, *Indian Fmg*, 1941, **2**, 124; Shah, ibid., 1946, **7**, 584; Shetty, *Madras agric. J.*, 1950, **37**, 126; Chandler, 1957, 380–81].

Planting and Culture—The plants are set at a distance of 5–7 m. from each other. To ward off attack by white ants, to which the peach is said to be very susceptible, the plants are irrigated immediately after planting, with water to which aldrin has been added at the rate of 10.5 g. per 10 litres of water. The peach orchard needs thorough cultivation and mulching with a cover crop grown during rainy season and ploughed under during winter. Application of inorganic fertilizers depends upon the age and growth of trees and type of soil. Trees in full bearing should make an annual growth of 30–45 cm. at the tips of leading branches to maintain maximum production, and enough fertilizers should be applied to bring about such a growth. Irrigation may be necessary in the dry and hot season and again after fruit set till harvesting time [Thapar, 106; Dewan, *Punjab hort. J.*, 1962, **2**, 96; Thakur, *Himachal Hort.*, 1962, **3**(4), 17; Katyal & Chadha, *Fertil. News*, 1963, **8**(8), 23; Bailey, 1947, III, 2496; Singh & Singh, loc. cit.].

Young peach trees planted as replacement in old peach orchards are sometimes stunted in growth. This is shown to be due to the toxic effect of substances in the soil produced by microbial breakdown of amygdalin contained in the residue of dead roots of the previous crop of peach trees. The roots of growing peach plants may also be attacked by nematodes, fungi and insects with similar results (Patrick, *Canad. J. Bot.*, 1955, **33**, 461; Mountain & Patrick, ibid., 1959, **37**, 459).

With the exception of a few types, the peach is self-fertile and can be planted in solid blocks. But better setting of fruit is said to be obtained if several types are planted in strips of two rows each. The provision of honey-beehives in the orchard will be helpful in pollination and fruit set. Artificial cross-pollination is reported to improve fruit set significantly (Talbert, 83; Chandler, 1957, 374; Randhawa *et al., Indian J. agric. Sci.*, 1963, **33**, 129).

Pruning—Pruning is done in young trees mainly to develop a strong framework and in old bearing trees to maintain a low bearing surface. The modified leader system has proved quite satisfactory, and is becoming more common than open centre system. In peach, fruits are borne laterally on one-year old wood or on short spur-like twigs. Judicious pruning is necessary to produce new wood annually. Peach tree requires in general more annual pruning than most other temperate fruit trees. Besides pruning, thinning is also done when fruits are set, in order to prevent breakage of branches by the weight of the fruit and obtain fruits of good marketable size. This is done soon after the natural drop has taken place in May–June, the distance allowed between fruits depending upon the type and condition of the tree and the size of fruits desired for the market [Thapar, 107–08; Sham Singh *et al.*, 336–37; Singh & Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1956, **6**(8), 15; Balbir Singh, *Indian Hort.*, 1962–63, **7**(2), 16; Srivastava, ibid., 1964–65, **9**(3), 11; Shoemaker & Teskey, 254–62].

Diseases and Pests—The peach is subject to a number of diseases and pests in this country. Leaf curl caused by the fungus *Taphrina deformans* (Berk.) Tul. is common in the hilly areas, where it acts as the main limiting factor in the expansion of peach cultivation; it is said to be absent in the plains. The leaf curl fungus is said to be usually found in association with the leaf curl aphid *Brachycaudus helichrysi* Kattenbach. The tree gets stunted and the infested leaves curled. Removal of infected parts and spraying the trees with lime sulphur or Bordeaux or Burgundy mixture or a suitable copper fungicide or wettable sulphur, before the

buds burst into leaf, is recommended. Mildew, caused by *Sphaerotheca pannosa* (Wallr.) Lev., infects leaves and fruits. Dusting with flowers of sulphur or spraying with lime sulphur is said to check this disease. Frosty mildew, caused by *Cercosporella persicae* Sacc., has been reported from Himachal Pradesh and stem-black disease, caused by *Coniothecium chomatosporum* Corda, is said to be prevalent in Kumaun. Mode of infection and control measures are similar to those in the case of the apple (cf. *Malus*). Rust, caused by *Puccinia prunispinosae* Pers., and shot hole or gum spot, caused by *Clasterosporium carpophilum* (Lev.) Aderh., are other diseases recorded affecting peach trees. A mixture containing the sulphates of copper, iron and zinc along with borax and unslaked lime dissolved in water is said to have proved very beneficial in Punjab as prophylactic spray against most of the diseases of leaves, branches, stem and bark [Singh & Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1956, **6**(8), 24 ; Singh, *Misc. Bull., imp. Coun. agric. Res.*, No. 51, 1942 ; Jain, *Himachal Hort.*, 1961–62, **2** & **3**, 179 ; ibid., 1962, **3**(4), 11 ; Sham Singh *et al.*, 351–52 ; Sohni *et al.*, *Indian Phytopath.*, 1964, **17**, 42 ; Anderson, 215, 256 ; Butler & Jones, 770, 762, 776, 779 ; Paracer, *Punjab hort. J.*, 1961, **1**, 169].

Tatter leaf disease, caused by a virus, is common in the hill regions of Punjab and Himachal Pradesh. The affected leaves are riddled with holes. Bacterial gummosis, caused by *Pseudomonas* sp., is frequently encountered on peaches and other stone fruits in some areas like Himachal Pradesh. The infected parts are removed and burnt and the wounds washed with spirit and dressed with Bordeaux paste (Nagaich & Vashisht, *Indian Phytopath.*, 1965, **18**, 288 ; Agarwala, *Himachal Hort.*, 1961, **2**, 49).

The following fungi have also been recorded on the peach in India: *Botryodiplodia persicae* Died., *Cladosporium carpophilum* Thum., *Fomes senex* Nees & Mont., *Oidium* sp., *Phyllosticta prunicola* Sacc., *Polyporus hispidus* Fr., *P. ostreiformis* Berk., *Polystictus steinheilianus* Berk. & Lev. (syn. *P. hirsutus* Fr.), *Rhizopus arrhizus* Fischer, *R. nigricans* Ehrenb., *Rosellinia* sp., *Sclerotinia cinerea* Schroet. and *Transzschelia punctata* (Pers.) Arth. (Butler, Bisby & Vasudeva, 435 ; *Indian J. agric. Sci.*, 1950, **20**, 107).

The peach leaf curl aphid, *Brachycaudus helichrysi* Kattenbach, is the most serious pest of the peach in India, local types being more susceptible than introduced American types. The pest migrates and breeds during summer on alternate hosts like *Ageratum conyzoides* and *Erigeron canadensis*. Spraying with nicotine sulphate or Diazinon is said to give effective control. The mealy aphid, *Hyalopterus pruni* Geoffroy (*H. arundinis* Fabr.) has been recorded from Punjab and Mysore. It is said to find optimum conditions for feeding and breeding continuously throughout the year at an elevation of about 1,200 m. but occurs as a minor pest at higher elevations. The fruits of the infested plants are often small and a large proportion of them fall off prematurely. Most of the contact poisons are ineffective but a rosin-tobacco mixture has been found to be satisfactory and cheap. The green aphid *Myzus persicae* Sulz., and the black aphid *Pterochlorus* (*Lachnus*) *persicae* Cholodkovsky are two minor pests on the stem and branches and their control is similar to that of the mealy aphid (Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 84 88 ; Singh, *Hort. Advance*, 1959, **3**, 123).

The scale insect *Pseudaulacapsis pentagona* Targioni is causing increasing damage in Kumaun and Assam ; similarly, the bug, *Lygaeus* (*Spilostethus*) *pandurus* Scop., is said to have become a regular pest of peach and other orchard fruits. Other insect pests recorded are: *Myllocerus undecim-pustulatus* Faust (weevil), *Sphenoptera lafertei* Thomson (buprestid borer), *Macrotoma crenata* Fabr. (peach borer), *Anarsia lineatella* Zeller (peach twig borer) and *Cacoecia epicyrta* Meyrick (leaf roller caterpillar). Young trees in the nursery and up to 2–3 years after setting in the orchard are liable to attack of a beetle, *Chrysobothris* sp., whose grubs develop in the bark (Pruthi & Batra, *Bull. Indian Coun. agric. Res.*, No. 80, 1960, 89, 91–92, 94-96, 99 ; Gupta, *Sci. & Cult.*, 1959–60, **25**, 446).

Harvesting and Yield—The peach crop comes to harvest from May to September. On the Nilgiri hills the crop comes to fruit in May–June but off-season bearing in November and December is also reported. Harvesting is done in different stages of maturity depending upon how the crop is to be marketed or utilized. Peaches are picked when they are still hard, as they ripen well in storage or transit. The profitable bearing life of the peach tree is comparatively short, i.e. 15 20 years. The yield per tree in India is reported to be about 40-80 kg. [Thapar, 109 ; Singh & Singh, *Agric. Anim. Husb., Uttar Pradesh*, 1956, **6**(8), 20 ; Dewan, *Punjab hort. J.*, 1962, **2**, 96 ; Saptharishi & Alwa, *Madras agric. J.*, 1953, **40**, 548 ; Shoemaker & Teskey, 265–72).

UTILIZATION AND CHEMICAL COMPOSITION

Peaches are a favourite table fruit, but being highly perishable, are hard to transport and store. Freestone peaches are soft and juicy when ripe and are mostly used as dessert; clingstone peaches are large, hard-fleshed and almost inedible in the raw state, but become delicious when cooked in syrup; they are mostly used for canning. In India, small quantities of peaches are processed in Uttar Pradesh (Table 3). In countries like U.S.A., Australia, South Africa, Canada and Japan, large quantities are canned, dried or frozen; beverages such as juice and nectar, or peach brandy are also prepared (Hill, 393; Stanford, 435; Information from the Directorate of Fruit Utilization, Uttar Pradesh).

Peaches are a fair source of sugars, thiamine and ascorbic acid; some types contain appreciable amounts of vitamin A. Ripe peaches from Coonoor markets contained 88 per cent of edible matter (flesh and skin), which on analysis gave: moisture, 86.0; protein, 1.2; fat, 0.3; fibre, 1.2; other carbohydrates, 10.5; and minerals, 0.8%; calcium, 15.0; magnesium, 21.0; oxalic acid, 1.0; iron, 2.4; total phosphorus, 41.0; phytin phosphorus, 1.0; sodium, 2.0; potassium, 453.0; copper, 0.06; sulphur, 26.0; vitamin A, nil; thiamine, 0.02; riboflavin, 0.03; nicotinic acid, 0.5; and ascorbic acid, 6.0 mg./100 g. Vitamin A values of ripe peaches from Delhi, Quetta, and Peshawar markets were recorded as 450, 1,360, and 1,660 I.U./100 g., respectively (Tressler & Joslyn, 449–51; Nutritive Value of Indian Foods, 72, 107, 136; Balasubramanian *et al.*, *Indian J. med. Res.*, 1962, **50**, 779; Sadana & Ahmed, *J. sci. industr. Res.*, 1949, **8B**, 35; Sherman, 691).

The average composition of flesh of the *Red Wing*, *Foster*, and *Red Nectarine* types of Indian peaches, grown in Chaubattia (Almora) is respectively as follows: total soluble solids (Brix), 11.0, 10.0, 10.5°; acidity, 0.51, 0.62, 0.46%; total sugars, 10.0, 8.5, 10.0%; reducing sugars, 3.0, 2.8, 2.0%; non-reducing sugars, 6.65, 5.3, 7.6%; and ascorbic acid, 1.4, 5.2, 9.8 mg./100 g. The acids present in peach are mainly malic and citric, the proportions of which vary enormously in fruit from different sources. American peaches contain on the average 5.7 per cent of sucrose and 2.0 per cent of reducing sugars, the corresponding values recorded for European peaches being 2–10 and 2–7 per cent respectively. During ripening of the fruit, there is a steady increase in both sucrose and reducing sugar contents, disappearance of starch, and the transformation of protopectin into pectin without appreciable change in the total pectic substances. An average of 0.86 per cent pectic substances is reported in ripe peach flesh. Tannin occurs in small amounts. A leucoanthocyanin has been isolated from peaches [Srivastava & Srivastava, *Allahabad Fmr*, 1966, **40**(1), 25; Thorpe, IX, 255; Kertesz, 310; *Chem. Abstr.*, 1965, **62**, 9697].

Esters of linalool with formic, acetic, pentanoic, and octanoic acids, together with traces of acetaldehyde were earlier reported to be the odorous constituents of peach pulp. Recent work has, however, shown the presence of several lactones to which has been attributed the basis of the characteristic peach flavour. The volatile components definitely identified in the fruit include γ-hexalactone, γ-heptalactone, γ-octalactone, γ-nonalactone, δ-decalactone, ethanol, hexanol, benzyl alcohol, acetaldehyde, benzaldehyde, acetic acid, pentanoic acid, hexanoic acids, hexyl formate, methyl acetate, ethyl acetate, pentyl acetate, hexyl acetate, *trans*-2-hexenyl acetate, benzyl acetate, ethyl benzoate, and hexyl benzoate (Nursten & Williams, *Chem. & Ind.*, 1967, 486).

Canned Peach—For canning, firm ripe mature fruits of maximum size are processed soon after picking; fruits to be held for some days are kept in cold storage at 0–2°. The peaches are cut and pitted by hand or machine, peeled by treatment with hot lye or steam, and washed. The peeled material is blanched in hot water or steam to remove traces of lye and to inactivate the oxidase responsible for the browning of surface. The fruits are then sorted, graded and sliced before filling in the cans. The total loss in weight of peaches in the canning process due to removal of pits and peel averages 30–35 per cent. Bulk of the ascorbic acid in the fruits is lost during lye peeling (Cruess, 136, 139–48; von Loesecke, 1942, 90; Dhopeshwarkar & Magar, *J. sci. industr. Res.*, 1954, **13B**, 349).

Peach Nectar—For the preparation of peach nectar, the puree obtained from peaches is blended with sugar syrup, and acidified with citric acid. Press peach juice is considered somewhat better than sugar syrup for the blending of puree. Canned peach nectar contains: moisture, 87 g.; carbohydrates, 31 g.; and calcium, 10; iron, 0.5; thiamine, 0.02; riboflavin, 0.05; nicotinic acid, 1.0; and ascorbic acid, 1.0 mg./100 g.; vitamin A value, 1,070 I.U./100 g. Protein and fat are present in traces (Tressler & Joslyn, 818–20, 938).

Dried Peach—Freestone peaches of large size and high sugar content with rich golden yellow flesh and

pleasing flavour are selected for sun drying. They are cut and pitted, exposed to sulphur fumes, and dried in the sun when a golden yellow product is obtained. Clingstone peaches are usually dried in dehydrators at 185–212°F. after lye peeling and sulphuring. Dried, sulphured peaches contain: water, 24.0; protein, 3.0; fat, 0.6; fibre, 3.5; other carbohydrates, 65.9; and ash, 3.0%; calcium, 44; phosphorus, 126; iron, 6.9; thiamine, 0.01; riboflavin, 0.2; niacin, 5.4; and ascorbic acid, 19 mg.: vitamin A value, 3,250 I.U./100 g. Dried peaches are used in the preparation of peach chutney. Cooked peaches are preserved with the addition of spice and sugar (von Loesecke, 1942, 470; Cruess, 380, 455–56, 495–96; Watt & Merrill, *Agric. Handb., U.S. Dep. Agric.*, No. 8, 1950, 37; Girdhari Lal *et al.*, 207).

Peach Kernel Oil—The peach pits which are available in considerable quantities in the canning and drying industries find limited use for fuel purposes or in poultry feeds. Pits yield 9–11 per cent of kernels which contain (dry matter basis): fat, 39.9; protein, 31.2; crude fibre, 14.8; sugars, 2.2; starch, 3.6; and mineral matter, 2.7%. Amygdalin occurs in the kernels to the extent of 2.35 per cent. As in almond, amandin is the principal protein in peach kernels. The kernels after removal of amygdalin by hydrolysis, are reported to be useful as substitute for almonds. They contain 32–45 per cent of a semi-drying oil, known as Peach Kernel Oil, which is used for the same purposes as Apricot Kernel Oil (q.v.). Because of the difficulty of drying and cracking peach pits, as compared with apricot pits, comparatively small amount of peach kernel oil is commercially prepared. The expressed peach oil has a yellow colour and a strong flavour and odour of benzaldehyde cyanhydrin. It can be easily refined. The characteristics of the oil are nearly the same as those of apricot kernel oil and are summarized in Table 1 (p. 255). Peach kernels from Naini Tal, on extraction with petroleum ether, gave 43.6 per cent of an odourless, pale yellow oil (iod. val. 85.4), the fatty acids of which comprised 94.2 per cent liquid and 5.8 per cent solid acids [Kester, *Yearb. Agric., U.S. Dep. Agric.*, 1950–51, 593; Wahhab & Khan, *Pakist. J. sci. Res.*, 1956, **8**, 80; Winton & Winton, I, 487; Eckey, 459; Jamieson, 173; Kirschenbauer, 198; Bush & Cagan, *Industr. Engng Chem.*, 1947, **39**, 1452; Dhar & Chauhan, *Agra Univ. J. Res. (Sci.)*, 1963, **12**(1), 1].

The press-cake obtained after the expression of fatty oil can be used as a source of oil of bitter almonds (q.v.). The yield of the essential oil is reported to be 0.7 per cent from the kernels. The cake (nitrogen, 7.9%) can be used as a fertilizer and after debittering as a cattlefeed [Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(10), suppl., 168–69; Wahhab & Khan, loc. cit.].

Peach pit shells on powdering form a soft grit useful in cleaning machine parts by blasting. On destructive distillation, they yield a high quality charcoal suitable for use in case hardening or heat treatment of steels by carburizing. An activated carbon comparable to Norrit A in its adsorptive capacity has been prepared from them (Clark & Lathrop, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC–352, 1953, 10, 23, 30; Wahhab & Khan, loc. cit.).

The seeds, flowers, leaves and bark have the odour and taste of bitter almonds, and on hydrolysis yield hydrocyanic acid. The leaves yield a volatile oil upon distillation and the distillation water prepared from the leaves contain 0.04–0.14 per cent of hydrocyanic acid. The leaves also contain a tannin-like substance (8%), quercitin, kaempferol, caffeic acid and *p*-coumaric acid. The leaves are said to be laxative and were formerly used as an anthelmintic. An infusion of leaves or bark is given in coughs, especially whooping cough. The leaves and blossoms as well as the kernels are poisonous. Peach flowers are stated to be purgative and anthelmintic. White flowers yield trifolin (kaempferol 3-galactoside) (U.S.D., 1955, 1019; Kirt. & Basu, II, 954; Chopra *et al.*, I, 364; Howes in Wiesner, Lieferung 1, 257; Bate-Smith, *J. Linn. Soc., Bot.*, 1961–64, **58**, 39; *Chem. Abstr.*, 1961, **55**, 14448).

Peach gum exuded from the tree is composed of 5 parts of D-galactose, 6 parts of L-arabinose, 2 parts of D-xylose, L-rhamnose (c. 2%), and 1 part of D-glucuronic acid. The root bark is said to have been used as the source of a dye. The timber of trees past bearing is used for building and other purposes (Smith & Montgomery, 272).

Trade—Very small quantities of fresh peaches have been exported in some years, but larger quantities of them are being imported annually, the main supplying country being West Pakistan; in recent years the import is either small or nil. Tables 4 and 5 give details of exports and imports of peaches during 1960–61 to 1967–68.

P. salicina Lindl. syn. *P. triflora* Roxb.
JAPANESE PLUM

Fl. Br. Ind., II, 315; Bailey, 1947, III, 2826, Fig. 3073–74, 3216.

A small, bushy tree with glabrous branches; leaves mostly oblong-ovate, abruptly acuminate, serrate, shining above and dull beneath; flowers white, 2–3, appearing clustered on the spurs; fruit mostly large and firm, ovoid globose, yellow or light red but never blue or purple, with deep suture; flesh reddish yellow.

It is a native of China and Burma and is said to have been introduced into Japan from where it was taken to U.S.A. Many types of the Japanese plum and its hybrids with other related species are said to be highly prized in parts of U.S.A. They are also reported to be cultivated in the Khasi and Jaintia hills for their fruit. A number of types of the Japanese plum have been introduced into India for cultivation in the Himalayan regions and in the Nilgiris. They are the only plums said to thrive in the Nilgiris where they have been found to be most prolific and remunerative at elevations ranging from about 1,400 to 1,800 m. The types successful there are: *Gaviota*, *Shiro*, *Abundance*, *Czar*, *Kelsey*, *Satsuma*, *Hale* and *Rubio*. Their cultivation in South India is, however, very limited (*c*. 60 ha.) and they are not as popular as apples, mainly because they are more easily perishable. Most of the plum types being grown in northern Indian areas, such as *Santa Rosa*, *Beauty*, *Kelsey*, *Bright Red*, *Burkbank* and *Satsuma* are also *P. salicina* types [Zielinski, 155; Naik, 330; Rao, *Madras agric. J.*, 1946, **34**, 44; Rajendra Singh, *Himachal Hort.*, 1961, **2**(3), 79].

The Japanese plums are more spreading in habit than the common plums (*P. domestica*) and the trees are hardy, very vigorous and very productive. They tolerate a variety of soils and climatic conditions and are said to have extended in America the area of profitable plum growing into districts where *P. domestica* had failed. Some types of the Japanese plum are said to have been acclimatized to sub-tropical conditions in the sub-montane districts of Punjab and Uttar Pradesh and they have even acquired vernacular names, though their original source and history are not clearly known. Morphological studies of a few of them have been carried out and trials under conditions obtaining at Delhi are said to have shown that some are suitable for commercial cultivation (Cullinan, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 703; Zielinski, 155; Bailey, 1947, III, 2715; Randhawa & Nair, *Indian J. Hort.*, 1960, **17**, 144).

The diploid chromosome number of *P. salicina* is said to be 16. It does not cross with *P. domestica*, but it has been crossed with *P. simonii* Carr. (Simon or Apricot Plum), to produce some very desirable hybrid types like *Wickson* and *Shiro* which have been introduced into this country. It has also been crossed with *P. munsoniana* W.F. Wight & Hedr., a native American plum, to give rise to some hybrids, one of which, *Excelsior*, has been introduced into this country. Several of the so-called plumcots are thought to be hybrids between *P. salicina* and *P. armeniaca* (Zielinski, 155–56; Chandler, 1957, 352).

The cultivation of the Japanese plum is similar to that of the common plum. Since many of the types are self-sterile, suitable interfertile types should be planted together. *Hale*, one of the types under cultivation in the Nilgiris has been found to be a suitable pollinator for most of the other types cultivated there. A few types of *P. domestica* are said to pollinate some types of *P. salicina* well enough to produce a good crop, but the pollen of the latter are unable to pollinate and cause fruit to set in *P. domestica*. Bees visit the blossoms eagerly and surplus honey is said to be collected from this source in the Nilgiris [Naik, 334–35; Kuppuswami, *S. Indian Hort.*, 1954, **2**(1), 14; Chandler, 1957, 350; Randhawa & Nair, *Indian J. Hort.*, 1960, **17**, 96; Singh, ibid., 1954, **11**(2), 49].

One-year old peach seedlings (probably of *P. persica* var. *compressa*) are very commonly used as rootstock to propagate the Japanese plums in the Nilgiris, by shield budding. However, all the types are not perfectly compatible on this peach and attempts have been made to use *P. cerasifera* var. *divaricata* Bailey as rootstock. Propagation by stem cuttings treated with β-indolyl butyric acid is said to have been successful. The Japanese plums can be top-worked on *P. domestica* and will make durable trees, but when it is done the other way, the *P. domestica* trees are said to be short lived. Japanese plum trees bear more heavily than those of the common plum. To secure fruits of good colour and size, pruning and thinning of fruits is necessary. An open-centre type of tree has been recommended for all Japanese plums grown at Coonoor. It is not advisable to shorten the spurs which are short and produce fruit buds only laterally, whereas lateral shoots which are mainly the spur producers can be shortened to stimulate spur production. Spurs can advantageously be thinned to spacing of about 15 cm. Trials on thinning of fruit at the marble stage of *Rubio*, a prolific type, is said to have resulted in increase of individual fruit size by about 50 per cent above normal, though gross yield was reduced by about 40 per cent. The other advan-

tages claimed for fruit thinning are a much higher price obtained by the larger fruit, better colour and more uniform ripening. Among Japanese plums the type *Beauty* demands most severe thinning, while *Santa Rosa*, only light thinning. The beneficial effect of thinning on the Japanese plum has been further confirmed by trials carried out in Simla hills. Hand thinning is said to have proved more effective than thinning with chemical sprays. Harvest of some early types begins in Coonoor towards the end of April and continues till June in some late types. Off-season bearing during December in some types has been reported from this area. In the Himalayan region, the different types are harvested in July–August. Yields up to a maximum of about 45 kg. of fruits per tree have been reported from Coonoor while in areas of Himachal Pradesh some prolific types yield as much as 110–150 kg. [Naik, 333–39; Rao, *Madras agric. J.*, 1946, **34,** 44; Chandler, 1957, 352; Dikshit, *Sci. & Cult.*, 1956–57, **22,** 391; Saptharishi & Azariah, *Madras agric. J.*, 1952, **39,** 455; Kirpal Singh & Bajwa, *Punjab hort. J.*, 1964, **4,** 23; Sham Singh *et al.*, 340; Balbir Singh, *Indian J. agric. Sci.*, 1961, **31,** 64; Rajendra Singh, *Himachal Hort.*, 1961, **2**(3), 79].

The fruit fly, *Dacus incisus* Wlk., and the San Jose scale, *Aspidiotus perniciosus* Comst., are reported to attack the plum in Coonoor (Naik, 340).

The storage life of harvested fruits is 20–28 days at 0–2°, depending on the type of the fruit. Post storage life at 20–21° was 5 days and at 22–29° (room temperature) 2–3 days (Srivastava & D'Souza, *Food Sci.*, 1962, **11,** 219).

The fruits are very large and attractive. The quality of the fruit is not equal to that of the best types of *P. domestica*, but the fresh fruit is said to be delicious in its blend of flavours, and is usually so firm that it transports well. Analysis of the edible matter (90–95% of the fruit) of *Shiro*, *Gaviota*, *Hale*, *Rubio* and *Satsuma* types obtained from the Pomological Station, Coonoor, gave the following ranges of values: moisture, 85.5–88.6; protein, 0.5–0.7; fat (ether extr.), 0.2–1.0; fibre, 0.3–0.7; other carbohydrates, 9.5–12.8; and mineral matter, 0.3–0.5%; calcium, 10–20; phosphorus, 10; iron, 0.3–0.6; vitamin C, 2–13; thiamine, 0.01–0.03; nicotinic acid, 0–0.6; and riboflavin, 0.03–0.19 mg./100 g.; carotene (as vitamin A), 42–608 I.U./100 g. [Nutritive Value of Indian Foods, 73, 108, 136; Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**(2&3), 151].

The fruit is considered stomachic and good for allaying thirst; it is given in arthritis (Kirt. & Basu, II, 965).

The bark of the tree contains β-sitosterol, myricyl alcohol, probably theogallin and two crystalline compounds (m.p. 98° and 117°) (Chakravarti & Chakravarti, *J. Indian chem. Soc.*, 1966, **43,** 65).

P. arborea (Blume) Kalkm. var. *montana* (Hook. f.) Kalkm. syn. *Pygeum montanum* Hook. f.; *P. ciliatum* Koehne; *P. ocellatum* Koehne (Khasi—*Dieng-chalawan-synrang*) is a small- to medium-sized tree, with white fragrant flowers, found in the eastern Himalayas and plains and hills of Assam up to altitudes of 1,650 m. The wood, which smells of bitter almonds, is reddish brown and seasons well, but is not reported to be used except for fuel [Kalkman, *Blumea*, 1965–66, **13,** 1; Fl. Assam, II, 187; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(10), suppl., 161].

P. jacquemontii Hook. f. is a dwarf shrub with small sharply serrate leaves, pink flowers and bright red fruit found in the western Himalayan areas of Garhwal and Kumaun at altitudes of 2,500–3,500 m. It is grown as an ornamental. The plant is said to be very much browsed down by sheep (Osmaston, 202).

P. javanica Miq. syn. *P. martabanica* Kurz is a large evergreen tree, up to 25 m. in height and 1.7–3.0 m. in girth, found in the South Andaman Islands and distributed in Burma and Malay Peninsula. It has a dark chocolate-brown bark peeling off easily from the sapwood and having a pleasant smell like that of the essence of almond. The wood (wt., 688.5 kg./cu.m.) is cross-grained, reddish yellow in colour and has an almond-like smell. The bark is reported to be used for rice bins and as vermicide (Parkinson, 162; Rodger, 35; Kalkman, *Blumea*, 1965–66, **13,** 1).

P. jenkinsii Hook. f. (Assam– *Bontheraju*, *dieng-soh-satang-hi*) is an evergreen medium-sized tree attaining about 17 m. in height, and possessing a dark grey or brown bark, lanceolate serrate leaves, white flowers in racemes and an ovoid or sub-globose acid fruit, c. 2.0 cm. long. The tree is found in Assam and is said to be sometimes cultivated for its fruits (Fl. Assam, II, 181).

P. prostrata Labill., a scraggy shrub, 1.5–1.8 m. high, with tomentose branches, elliptic or ovate-oblong serrate leaves, pink flowers and ovoid fruits 0.75 cm. long, is found in the inner valleys of western Himalayas like Chamba, Pangi and Lahul at altitudes of 1,500–3,000 m. The fruit which has a scanty juicy

pulp when ripe is said to be eaten, though not very palatable.

P. rufa Hook. f. (North Bengal—*Lekh paiyun*) is a small tree, 4–6 m. high, with smooth reddish papery bark and very sharply serrate leaves, pink flowers and black or red fleshy bitter fruits. It is found in the central and eastern temperate Himalayan regions of Nepal, Sikkim and Bhutan at altitudes of 2,700–3,600 m. The wood is said to be reddish, hard, close-grained and sweet scented.

P. serotina Ehrhart, a native of North America, is the source of Wild Cherry Bark said to be popularly employed to relieve cough in phthisis and bronchitis. Attempts to cultivate this plant in this country on an experimental basis have not met with success (Kapoor & Handa, *Curr. Sci.*, 1948, **17,** 54; Information from Dr. L. D. Kapoor, National Botanic Gardens, Lucknow).

P. serrulata Lindl. (Japanese Flowering Cherry) includes a large number of forms with white, red or yellowish green flowers and some which are double flowered. The tree is reported to be grown in Nilgiris and is said to come up better in Coonoor than at Ootacamund. They grow into stately trees and give good shade during summer (Bailey, 1947, III, 2838; Krishnamurthi, 223).

P. tomentosa Thunb. is a shrub or small tree with branches spreading wide, pubescent tomentose when young, said to be found in North-West Himalayas in Kashmir and Ladakh at altitudes of 1,500–1,800 m. It bears small light red sparsely hairy, globular fruits, about 1.0 cm. in diameter. The fruits are said to be eaten. The tree is hardy and it is possible to evolve improved fruit-bearing races (Bailey, 1947, III, 2835).

P. undulata Buch.-Ham. ex D. Don (Garhwal—*Aria, gadharu*; Khasi—*Dieng-lyrkhun*), a medium-sized deciduous tree with rounded crown, white flowers and ovoid drupes, is found in the temperate Himalayan regions from Kumaun to Assam at altitudes of 1,800–3,600 m. The leaves and fruits contain a hydrocyanic acid-yielding substance and are reported to be poisonous to cattle [Rao, *Bull. bot. Surv. India*, 1959, **1**(1), 107; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(10), suppl., 169; Purohit, *Indian Live-Stk*, 1963, **1**(2), 28].

P. wallichii Steud. syn. *P. acuminata* Dietr. non Michx., a small tree or shrub c. 12 m. high, bearing white and fragrant flowers and purplish black fruits, occurs in central and eastern Himalayas from Nepal to Sikkim and in Mishmi and Khasi hills in Assam. The fruits are reported as edible. The wood is reddish brown, with pretty silver grain in radial section, takes a fine polish and has been used for planking and boxes in Darjeeling district (Kalkman, *Blumea*, 1965–66, **13,** 1; Fl. Assam, II, 182).

P. zippeliana Miq. syn. *P. macrophylla* Sieb. et Zucc. non Poir. is a tree, *c.* 30 m. tall, with stem sometimes longitudinally fissured, oblong-ovate leaves and cream coloured or white flowers in spicate inflorescences, and dark violet fruits. It is found in Naga hills in Assam and is distributed in Burma, South China and Japan. The leaves are reported to be of medicinal value (Chatterjee & Raizada, *Indian For.*, 1948, **74,** 385; Kalkman, loc. cit.; Fl. Japan, 442).

PSAMMOGETON Edgew. (*Umbelliferae*)

D.E.P., VI(1), 351; Fl. Br. Ind., II, 719; Hiroe, 37.

A small genus of herbs distributed in West Asia. One species occurs in India.

P. canescens Vatke syn. *P. biternatum* Edgew. (Punjab—*Gargira*) is a small, velvety or smooth, divaricately branched herb, 5–20 cm. high, with bipinnate to ternate pinnate leaves, and white or purplish flowers found in the western Himalayas up to 900 m. and in Punjab, Rajasthan and Uttar Pradesh.

The plant is eaten by sheep. It is used as a stomachic (Burkill, 1909, 36; Kirt. & Basu, II, 1231).

PSEUDANTHISTIRIA Hook. f. (*Gramineae*)

Fl. Br. Ind., VII, 219; Blatter & McCann, 120, Pl. 76.

A small genus of annual grasses found in the Indo-Malayan region. Four species are recorded in India.

P. heteroclita (Roxb.) Hook. f. (Guj. *Jhinkuphul ghas*), is a slender, geniculate grass, about 30–60 cm. high, found commonly in pastures in West Bengal, Maharashtra and Madras.

The grass grows gregariously on recently exposed soil and is used chiefly for thatching. The grass collected from pastures in over-ripe stage gave on analysis the following values: crude protein, 3.1; ash, 9.18; insol. ash, 6.25; calcium, 0.29; and phosphorus, 0.07%. The grass contains: carotene, 0.88–5.0 mg./100 g. (fresh wt. basis); cobalt, 0.8; zinc, 13.57; molybdenum, 0.04; and iodine, 0.02 p.p.m. (dry wt. basis) (Bor, 1960, 203; Shankar & Bharucha, *Indian J. agric. Sci.*, 1962, **32,** 9; Bharucha & Shankarnarayan, *Sci. & Cult.*, 1957–58, **23,** 311; Iyer & Satyanarayan, *Curr. Sci.*, 1958, **27,** 69, 220; Iyer, ibid., 1958, **27,** 408).

PSEUDARTHRIA Wight & Arn. (*Leguminosae; Papilionaceae*)

A small genus of herbs or undershrubs distributed in tropical Asia and Africa. One species is recorded in India.

P. viscida Wight & Arn.

Fl. Br. Ind., II, 154; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 2, 1953, 92–95, Fig.

SANS.—*Sanaparni;* GUJ.—*Chapakno velo;* TEL.—*Muyyakuponna, nayakuponna;* TAM.—*Neermalli;* MAL.—*Muvila.*

A viscid, pubescent, semi-erect or more often diffusely creeping, perennial undershrub, 60–120 cm. long, found in Orissa, throughout South India ascending up to an altitude of 900 m. in the hills, and in Gujarat. Leaves pinnately 3-foliolate: leaflets rhomboid-ovate; flowers purplish or pink, in clusters; pods linear-oblong, with sticky hairs; seeds brownish black.

The roots of the plant possess an astringent taste and are reported to be used as a substitute for the roots of *Desmodium gangeticum* (*Shalaparni*) in Kerala. They are used in the form of decoction or powder for biliousness, rheumatism, excessive heat and fever, diarrhoea, asthma, heart diseases, worms and piles (Rama Rao, 114; Kirt. & Basu, I, 749).

PSEUDECHINOLAENA Stapf (*Gramineae*)

Fl. Br. Ind., VII, 58; Bor, 1960, 352.

A monotypic genus found throughout the tropics of the world. *P. polystachya* Stapf (syn. *Panicum uncinatum* Raddi), a shade-loving grass, is found in the eastern Himalayas from Nepal to Sikkim at altitudes of 900–1,800 m. and in Khasi and Naga hills and hills of western ghats from North Kanara southwards at altitudes of 600–1,800 m. It is a perennial grass with culms about 60 cm. long, half of it prostrate, the other half rising above ground, and with numerous short or long branches; leaves lanceolate and acuminate, with scattered stiff hairs above, finely pubescent beneath; spikelets often unequally developed.

It is a typical hill forest grass, often forming thick masses in secondary jungles. The leafy parts, though little, are readily eaten by animals (Blatter & McCann, 131; Burkill, II, 1812).

PSEUDERANTHEMUM Radlk. (*Acanthaceae*)

A large genus of shrubs and subshrubs distributed throughout the tropics. Six species are found in India, of which one, *P. bicolor,* is an introduced plant.

P. bicolor Radlk. ex Lindau syn. *P. pulchellum* Merrill; *Eranthemum bicolor* Schrank

Bailey, 1949, 921.

A small shrub, 60–90 cm. high, native of Polynesia, grown in gardens in India. Leaves elliptic-ovate to oblong-lanceolate; flowers white with lower lobes spotted purple, in clusters, on elongating axillary and terminal unbranched spikes; fruit a hairy, stalked capsule, about 2 cm. long.

Analysis of the plant (as a vegetable) gave the following values: moisture, 85.0; protein, 3.4; fat, 0.2; total carbohydrates, 10.1; fibre, 1.7; ash, 1.3%; calcium, 275; phosphorus, 67; iron, 10.7 mg.; vitamin A, 4,340 I.U.; thiamine, 0.02; riboflavin, 0.10; nicotinic acid, 1.4; and ascorbic acid, 51 mg./100 g. A decoction of roots, stems and leaves of the plant is used for aphthae, and as a cicatrizant of wounds, ulcers, etc. (*Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 22; Quisumbing, 891).

P. racemosum Radlk., a small undershrub, native of Moluccas, bearing pretty flowers, is said to be grown in gardens. The leaves of the plant contain 3.5–4.0 per cent of protein (Firminger, 407; Terra, *Bull. R. trop. Inst., Amst.*, No. 283, 1964, 97).

PSEUDOSTACHYUM Munro (*Gramineae*)

A monotypic genus of bamboos probably confined to Indo-Burmese region.

P. polymorphum Munro

D.E.P., VI(1), 351; Fl. Br. Ind., VII, 409.

ASSAM—*Bajal, basal, tolli, nal;* LEPCHA—*Parphok, purphiok, paphok;* NEPAL—*Pheling.*

A shrubby, often sub-scandent bamboo found in Terai and lower hills of the eastern Himalayas from Sikkim eastwards, ascending up to an altitude of c. 1,800 m.; it is also found in Manipur and Assam valley, being particularly common at the foot of the Naga hills. Culms up to 17 m. long, arising singly from a creeping rhizome, lower parts branchless, nodes only slightly swollen, internodes up to 30 cm. long and 5 cm. in diam.; inflorescence a very large leafy panicle, composed of branches fascicled at the nodes.

The culms are easy to split, flexible and durable. They are employed for tying rafters in the construction of huts, and for making baskets and mats used in the tea plantations and in the betel leaf cultivation. The bamboo is also used for making umbrella handles and walking sticks; the culms can be made into the desired shape by bending them over heated iron rods.

The shoots are attacked by the borer *Cryptotrachelus dux* Boheman [Uphof, 298; Trotter, 1940, 241; Trotter, 1944, 228; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 73].

Pseudostreblus — *see* **Streblus**

PSEUDOTSUGA Carr. (*Pinaceae*)

A genus of evergreen trees distributed in the Pacific North American region and in China and Japan. *P. menziesii*, a well known structural timber tree of North America, has been introduced into India.

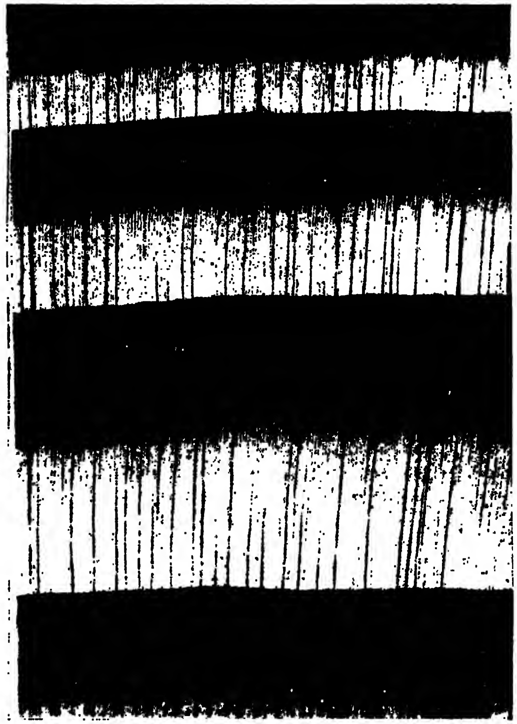
P. menziesii Franco syn. *P. taxifolia* Britton; *P. douglasii* Carr. GREEN DOUGLAS FIR, OREGON PINE

Dallimore & Jackson, 386, 589–92, Fig. 106.

A tall graceful tree, exceeding 100 m. in height and 12 m. in girth in its natural habitat, but on an average the trees in the forest are much smaller. Bark smooth, on old trees thick and corky, up to 30 cm. thick; leaves pectinate, 2–3 cm. long, arranged in two lateral rows, odorous; male flowers in orange catkins, female cones, 7–10 cm. × 3.5–5.0 cm., oval-ovate, pendulous; seeds dark brown, shining, mottled beneath.

In India, the Douglas Fir has been introduced with some success at Manali and the neighbouring hills at altitudes of 1,800–2,000 m.; it does not thrive at higher altitudes, as the young trees are prone to frost. Propagation may be done through sowing the seeds at site or by transplanting nursery-grown seedlings. In India, three-year old seedlings gave best results. The tree grows at a fast rate and, in its natural habitat, it yields a greater crop of lumber per hectare than any other species (Sahni, *Indian For.*, 1965, **91**, 56; Information from the Divisional Forest Officer, Punjab; Bailey, 1947, III, 2846).

The wood is very variable in quality, the colour of the heartwood varying from pinkish brown to brownish yellow and red. It is generally straight-grained, hard, strong, durable, and light to moderately heavy (sp. gr., 0.43–0.50; wt., 481–560 kg./cu.m.). The sawn timber can be readily air-seasoned without much deterioration; in kiln-seasoning also the timber does not show much degrade. The wood can be easily worked to a good finish, and it takes paint and polish well, but the grain is apt to rise. The data for the comparative suitability of timbers from coastal and mountain areas of U.S.A., respectively, expressed as percentages of the same properties of teak, are: wt., 80, 70; strength as a beam, 70, 60; stiffness as a beam, 95, 70; suitability as a post, 90, 70; retention of shape, 67, 75; shear, 85, 80; and hardness, 55, 50 (Streets, 645; Howard, 464; *Home-Grown Timbers: Douglas Fir*, Forest Products Research Laboratory, Department of Scientific and Industrial Research, U.K., 1964, 5–7; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 64, Sheet No. 23).



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 102—PSEUDOTSUGA MENZIESII—TRANSVERSE SECTION OF WOOD (×10)

The wood is used for purposes requiring much strength, such as house and bridge construction, masts and spars, telegraph and other poles, railway carriages, flooring, and cooperage, and for sleepers after treatment. It is also used for furniture, joinery, veneers, boxes, and wood pulp. The wood flour is sometimes used in the preparation of rotenone-bearing insecticides for its synergistic action (Streets, 645; Howard, 465; Hill, 90; *Chem. Abstr.*, 1946, **40**, 163).

The timber is imported into India (Table 1); it is available in large sizes, viz. logs, scantlings and planks, free from sapwood and knots.

It is stated that timbers from the species of *Abies*, *Picea* and *Pinus*, and also from *Artocarpus chaplasha*, *Calophyllum elatum*, and *Cedrus deodara* may be

TABLE 1—IMPORT OF DOUGLAS FIR TIMBER

(Qty in tonnes and Val. in Rs.)

Year	Country	Qty	Val.
1962-63	U.S.A.	42*	44,161
1963-64	U.S.A.	332*	291,904
1964-65	U.S.A.	265*	357,285
1965-66	U.S.A.	234	166,340
	Canada	162	127,657
1966-67	U.S.A.	73	99,307

* wt. calculated at 520 kg./cu.m.

used as substitutes for the imported coastal type Douglas Fir (Limaye, loc. cit.).

The bark of the Douglas Fir is processed for use as a substitute for cork in making plastics, adhesives, and explosives. It is also reported to possess insecticidal properties. The ground bark contains (oven-dry basis): wax, 3.5–6.0; tannin, 8–18; phenolic compounds, 12.5–17.0; and dihydroquercetin, 12%. The hard non-tacky wax (m.p. 60-62°), extracted from the bark, finds application in polishes, lubricants, ointments, and soap manufacture. The tannin extract is utilized in leather making. The use of bark in the manufacture of hardboard eliminates the need of adding chemicals as sizing agents. It is also suitable for use in conditioning oil-well drilling fluids [Hill, 90; Mirov, *Chemurg. Dig.*, 1950, **9**(7), 7; *Chem. Abstr.*, 1948, **42,** 7977; 1950, **44,** 11088; 1954, **48,** 1659; Anderson, *Econ. Bot.*, 1955, **9,** 120].

The tree yields an oleoresin, known as OREGON BALSAM, which has properties and uses more or less similar to those of Canada Balsam, and is used as a cement for lenses. It is, however, not recommended for microscopic technique, since it gradually becomes granular and opaque. Essential oils occur in the leaves and twigs (0.8%), bark from young trees (1%), and wood (3.3%). Terpenes are the chief constituents of these oils and of the balsam (Claus, 1961, 274; *Chem. Abstr.*, 1937, **31,** 5106, 5946, 6818; Zavarin & Snajberk, *Phytochemistry*, 1965, **4,** 141).

Young twigs and leaves are used for making a kind of tea, or are dried and ground as a coffee substitute. The tree is reported to yield a manna. The inner bark is said to be eaten (Morton, *Econ. Bot.*, 1963, **17,** 326; Harrison, *Kew Bull.*, 1950–51, 411).

The presence of antibacterial substances, inhibiting the growth of Gram-positive micro-organisms, has been noted in the seeds and fruits (*For. Abstr.*, 1957, **18,** 18).

PSIDIUM Linn. (*Myrtaceae*)

A large genus of tropical and sub-tropical trees and shrubs, native of tropical America. Three species are recorded as cultivated in India, the most important of which is *P. guajava* (COMMON GUAVA).

P. cattleyanum Sabine syn. *P. littorale* Raddi; *P. chinense* Hort. STRAWBERRY GUAVA, CATTLEY GUAVA

Bailey, 1947, III, 2848; Fl. Delhi, 160; Chittenden, III, 1705, Fig.

BENG.—*Pahari payara*; TEL.—*Konda jamipandu*; TAM.—*Seemai koyya*; KAN.—*Bella seebai*; MAL.—*Malam perakka*; ORIYA—*Pahadi pijuli*.

A bushy plant, 3.0–3.5 m. high, native of Brazil, and cultivated in gardens in India for its fruits. Leaves smooth, glossy green, obovate, 3.75–8.75 cm. long; fruit deep claret, round or obovate, rarely exceeding 3.75 cm. in diameter, with soft flesh, purplish red next to the skin, white in the middle. Two forms of this species are well known, one bearing coppery red fruits and the other bearing slightly larger, yellow fruits. The latter is commonly known as *P. cattleyanum* forma *lucidum* Degener (YELLOW STRAWBERRY GUAVA) (Chandler, 295; Neal, 556).

P. cattleyanum is perhaps the hardiest species, as mature plants can withstand temperatures down to −5°. It is suited to localities too cold for *P. guajava*. In India, it is said to be suitable for elevations up to

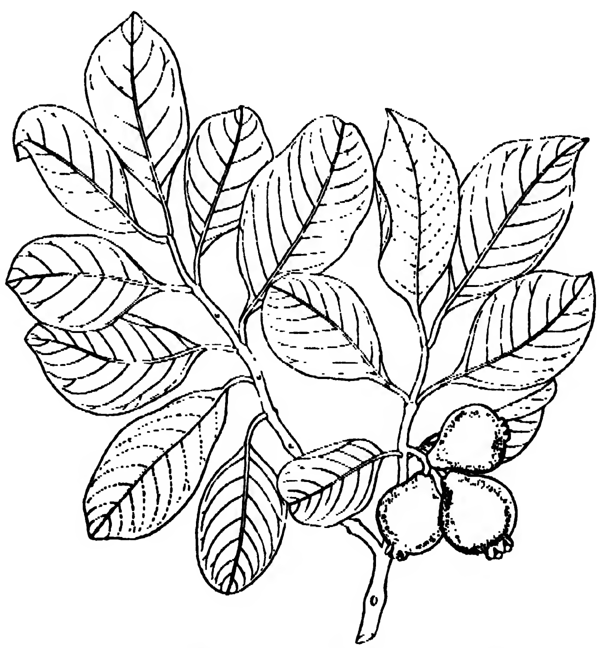


FIG. 103—PSIDIUM CATTLEYANUM—FRUITING BRANCH

1,350 m. It is propagated from seeds or by layering or grafting. However, it is not easy to propagate vegetatively; it comes up true to seed (Ochse *et al.*, I, 689; Macmillan, 275; Gopalaswamiengar, 607; Firminger, 203; Chandler, 295).

The fruits have a sweet, acid flavour resembling that of strawberries. They are eaten fresh or made into excellent tart, jam and jelly. They are also served as a dessert with sugar and cream (Burkill, II, 1815; Macmillan, 275; Ledin, *Econ. Bot.*, 1957, **11**, 349).

The fruits are a good source of ascorbic acid. They contain: moisture, 85.3; protein, 0.1; fat, 0.2; fibre, 4.8; other carbohydrates, 9.0; and mineral matter, 0.6%; calcium, 50; phosphorus, 20; iron, 1.2; vitamin A, nil; thiamine, 0.02; riboflavin, 0.02; nicotinic acid, 0.3; and ascorbic acid, 15 mg./100 g. The vitamin values of another sample were as follows: vitamin A, 147 I.U.; thiamine, 0.01 mg.; riboflavin, 0.26 mg.; nicotinic acid, nil; and ascorbic acid, 44 mg./100 g. (Nutritive Value of Indian Foods, 68, 103, 133).

P. guajava Linn. COMMON GUAVA

D.E.P., VI(1), 351; C.P., 907; Fl. Br. Ind., II, 468.

HINDI—*Amrud, safed safari*; BENG.—*Goaachhi, peyara, piyara*; MAR.—*Jamba, tupkel*; GUJ.—*Jamrud, jamrukh, peru*; TEL.—*Ettajama, goyya, tellajama*; TAM.—*Koyya*; KAN.—*Sebe hannu, jama phala*; MAL.—*Pera, koyya*.

An arborescent shrub or small tree, up to 8.0 m. high; leaves light green, finely pubescent and chartaceous; flowers white and fragrant; fruits green to light yellow, but in some varieties, red, varying in shape and size to a great extent; flesh creamish white to yellow and in some red.

Guava is often referred to as the apple of the tropics; it is a native of tropical America, probably from Mexico to Peru, and has long been naturalized in India. Many varieties are known in cultivation, but a detailed horticultural and systematic study of the species and its varieties is still lacking. Sometimes two varieties are broadly distinguished, var. *pyriferum* and var. *pomiferum* based on the shape of the fruits, whether pear-shaped or globose and ovoid. However, they are no longer accorded botanical standing. *P. guajava* is closely similar to *P. guineense* and possibility of hybridization between them seems likely, as they are highly variable with respect to fruit characters, and are also cultivated throughout the tropics (Wilson, *J. Arnold Arbor.*, 1960, **41**, 270; Bailey, 1947, III, 2848; McVaugh, *Publ. Field Mus. nat. Hist., Bot. Ser.*, 1958, **13**, pt 4, No. 2, 795).

CULTIVATION

Guava grows nearly throughout the country up to 1,500 m. and is cultivated commercially in almost all States, the total estimated area being about 50,000 hectares. The important guava growing States are: Uttar Pradesh, Bihar, Maharashtra, Assam, West Bengal, Andhra Pradesh and Madras; about half of the total area is reported in Uttar Pradesh (Sham Singh *et al.*, 155; Cheema *et al.*, 245; Hayes, 287).

Guava types are generally named according to the fruit shape, colour of the skin or pulp, or the name of the place where selected. As guava is propagated by seeds, there exists great variation in the same variety. Numerous attempts have been made to classify the various types cultivated in different States, particularly in Maharashtra, Uttar Pradesh, Bihar and Assam. Table 1 gives some of the types grown in the different States. Table 2 gives the salient characters of some popular types. Seedless types are reported from various States; they are shy bearers and their fruits are reported to be inferior in quality [Cheema *et al.*, 345; Dutta, *Indian J. Hort.*, 1953, **10**, 137; Hayes, 287; Naithani & Chandra, *Sci. & Cult.*, 1954–55, **20**, 133; Naithani & Srivastava, *Allahabad Fmr*, 1965, **39**(2), 65; Ramasomayajulu, *Indian J. Hort.*, 1953, **10**, 154; Roy *et al.*, ibid., 1951, **8**, 23;

TABLE 1—TYPES OF GUAVA GROWN IN DIFFERENT STATES IN INDIA*

State	Types
Andhra Pradesh	Allahabad Safeda, Anakapalli, Banarasi, Chittidar, Hafsi (Red-fleshed), Lucknow-46, Lucknow-49, Nagpur Seedless, Saharanpur Seedless, Smooth Green, Smooth White
Assam	Am-sophri, Madhuri-am, Safri (Payera), Soh-pryiam
Bihar	Allahabad Safeda, Chittidar, Hafsi (Red-fleshed), Hari Jha, Seedless
Madras	Anakapalli, Banarasi, Bangalore, Chittidar, Hafsi (Red-fleshed), Nagpur Seedless, Smooth Green
Maharashtra & Gujarat	Dharwar, Dholka, Kothrud, Lucknow-24, Lucknow-26, Nasik Seedless, Sindh
Uttar Pradesh	Allahabad Safeda, Apple-colour, Chittidar, Hafsi (Red-fleshed), Karela, Lucknow-49, Mirzapuri, Pear-shaped, Seedless
West Bengal	Barnipore and other Uttar Pradesh types

* Teaotia, *Spec. Bull., Dep. Agric., Uttar Pradesh*, 1959; Gandhi, *Farm Bull.*, No. 26, 1957, 4; Dutta, *Indian J. Hort.*, 1953, **10**(4), 1; Roy & Ahmed, ibid., 1951, **8**(3), 22; Naithani & Srivastava, *Allahabad Fmr*, 1965, **39**(2), 65; Mathew & Shanker, ibid., 1963, **37**(6), 127; Rangacharlu, *Andhra agric. J.*, 1954, **1**, 105.

TABLE 2—CHARACTERISTICS OF SOME TYPES OF GUAVA GROWN IN INDIA*

Type	Where grown	Plant characters	Remarks
Allahabad Safeda	Allahabad district in Uttar Pradesh, Bihar, Andhra Pradesh	Tree 4.5-6.0 m. in height, growth upright & spreading with moderately-dense foliage; fruit medium, roundish, surface smooth, glossy, skin colour yellow, dots small & distinct; apex flat, round; taste sweet; weight c. 168 g.	Best type grown for its fruit quality & fruiting; a heavy bearer with medium keeping quality
Apple-colour	Indigenous to Allahabad district in Uttar Pradesh	Tree 3.0-4.5 m. in height, spreading with moderately-dense foliage; fruit medium, round to spherical; surface slightly rough, skin colour light red or pinkish (apple like colour), thin, dots scattered; base slightly flat; apex round; flesh creamy white, soft-melting; flavour pleasant; taste sweet; weight c. 152 g.	Good type but not grown commercially due to its shy-bearing habit; special feature is the apple-like colour which is very attractive; has good keeping quality
Chittidar	Allahabad district in Uttar Pradesh, Bihar, Andhra Pradesh, Madras	Tree 3.0-4.5 m. tall, upright with dense growth; fruit medium, roundish ovate, apex round & flat; base obtuse & slightly tapering; flesh yellowish white, soft melting; flavour mild; taste acidic, sweet	Medium-quality fruit with good keeping quality; it is a medium bearer & is not much different from the Allahabad Safeda except for the red spots on the fruit skin
Hafsi (Red-fleshed)	Allahabad district in Uttar Pradesh, Bihar, Andhra Pradesh, Madras	Tree 4.5-7.5 m. in height, growth upright, moderately dense foliage; fruit medium, ovate roundish, surface smooth, glossy, skin colour greenish, yellow or pinkish yellow, dots small & close; apex obtuse; base flat; flesh reddish in colour, soft melting; flavour pleasant like apricot; taste acidic, sweet; weight c. 168 g.	Heavy bearer; a commercial type wel known for its red flesh
Hari Jha	Bihar	Short tree c. 2 m. tall, spreading branches; fruit greenish yellow, round, oblate, medium to large; pulp soft white, sweet & aromatic	Good yielder
Karela	Uttar Pradesh	Fruit large-terminate to pyriform, surface rough, warty, somewhat longitudinally furrowed, greenish yellow in colour, skin thick, dots small; base slightly tapering; apex obtuse; flesh white & granular, soft melting; flavour pleasant & very rich; taste sweet	Origin of this type is not known; has medium-quality fruit with medium to good keeping quality; poor bearer
Lucknow 49	Grown in Maharashtra, Andhra Pradesh & Uttar Pradesh	Tree 6.0-7.5 m. tall, upright to spreading with dense foliage; fruit medium to large, ovate, round, surface slightly rough, skin yellowish white, thick, dots medium & distinct; apex & base roundish; flesh creamy white, soft melting; flavour slightly acidic; taste acidic, sweet; weight c. 168 g.	Selection from Allahabad Safeda made at Poona; heavy bearer with very good keeping quality; a commercial type in Maharashtra & South India
Mirzapuri	Indigenous to Mirzapur district in Uttar Pradesh	Tree 3.0-4.5 m. tall with spreading growth; fruit medium, roundish, surface smooth; dots scattered; apex round; base conical; pulp soft when fully ripe, white; flavour mild; taste medium acidic, sweet	Seedling of Allahabad Safeda; medium bearer with medium quality fruit having good keeping quality
Seedless	Allahabad district in Uttar Pradesh, Bihar, Andhra Pradesh, Maharashtra	Tree 6.0-7.5 m. in height, growth upright, foliage dense; fruit medium, pyriform, occasionally ovoid, surface almost smooth or minutely warty, skin colour dull yellow; apex obtuse; base slightly depressed; pulp white, semi-hard, soft when fully ripe; taste sweet	A poor yielder but is well known for its excellent quality & seedlessness

* Teaotia, *Spec. Bull., Dep. Agric., Uttar Pradesh*, 1959; Naithani & Srivastava, *Allahabad Fmr*, 1965, **39**(2), 65; Roy & Ahmed, *Indian J. Hort.*, 1951, **8**(3), 22; Gandhi, *Farm Bull.*, No. 26, 1957, 4.

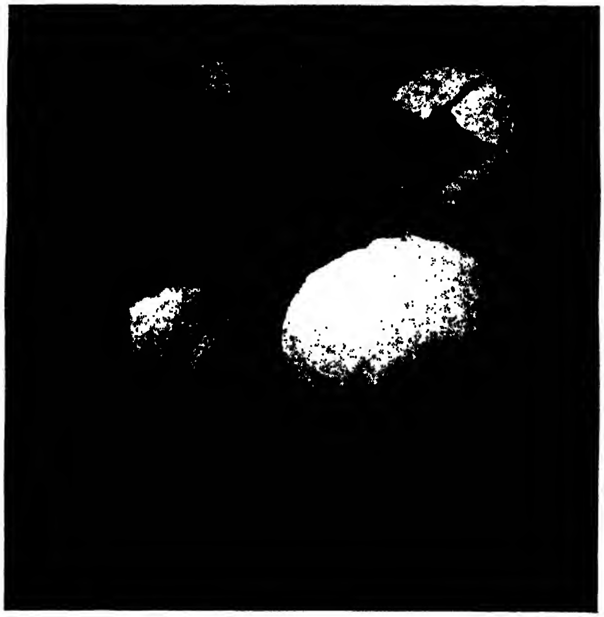


FIG. 104—PSIDIUM GUAJAVA—FRUITING BRANCH

Sharma, *Indian Hort.*, 1959–60, **4**(4), 6 ; Teaotia, *Spec. Bull., Dep. Agric., Uttar Pradesh*, 1959, 11 ; Sehgal & Singh, *Indian J. Hort.*, 1965, **22**, 25].

Guava succeeds under a wide variety of climatic conditions. Though highly susceptible to frost, it produces abundant crop of better quality fruits in areas having a distinct winter than in more tropical areas. It is highly resistant to drought in comparison with other fruit plants. Guava can be grown on a variety of soils, from heavy clay to very light soils. It thrives best on sandy loam (Ruehle, *Econ. Bot.*, 1948, **2**, 306 : Bailey, 1947, III, 2847 ; Hayes, 287 ; Popenoe, 273).

Propagation—Guava is propagated both by seeds and by cuttings. The fruits from seedlings are apt to vary in shape, size, and quality, but still the major plantings of guava are of seedling origin. Guava seeds retain their viability for several months, but it is desirable to sow them within the same year. Seeds germinate in 3–4 weeks in warm days. They are sown either in pots or in lines, and seedlings transplanted when about 5.0 7.5 cm. in height. Under favourable conditions the seedlings are ready for transplanting in the field or for grafting within a year.

In North India, inarching or grafting by approach is the commercial method adopted for improvement of guava. The best time for this operation is the rainy season. Union is complete within a month of the operation. After severing the graft from the mother plant, the plant is kept for about 4–5 months in the nursery before it is permanently planted in the field. Air layering has been found successful and has been adopted on a commercial scale in South India. Application of a small amount of Serdix powder on the upper portion of the ring is helpful in inducing vigorous rooting. Budding has not proved successful in guava in this country. Shield budding is successful if buds 2.5–3.75 cm. long are inserted in the winter or early spring into young rootstocks, with bark just thick enough to receive them. Propagation by soft wood cutting has also proved successful in some of the commercial types (Cheema *et al.*, 245 : Hayes, 289 ; Nelson, *Hort. Advance*, 1958, **2**, 61 ; Teaotia, loc. cit.).

The rainy season is best suited for planting, though guava can be planted at any time of the year if irrigation facilities are available. Seedlings are generally planted 4.8–5.4 m. apart, grafted trees requiring a distance of 6.0–7.5 m. (Gandhi, *Farm Bull.*, No. 26, 1957, 10).

Ordinarily, guava is given very little care and it does remarkably well in spite of this neglect. In order to get satisfactory crops, some amount of cultivation, irrigation and manuring is desirable, at least in the early stages. In western India, besides the average rainfall of 40 cm., 7–10 irrigations per year are found useful. One or two irrigations given after the fruit-set increase the size of the fruit and check the fruit-drop (Cheema *et al.*, 252).

Manuring—Proper manuring improves the size and quality of the fruit, as also the bearing life of the trees. Based on the experience of horticulturists and fruit growers, the following practices are advocated: (*i*) application of sufficient quantity of wood ash to seed beds, for raising seedlings ; (*ii*) a liberal application of farmyard manure, about 12.5 kg. per pit at the time of planting ; and (*iii*) application of a continuing dosage of farmyard manure from 12.5 kg. to an year-old tree, increased to an annual maintenance dose of 50 kg. from the 4th year. In addition, about 1.5 kg. of nitrogen, in the form of ammonium sulphate, may be given per tree per year. Trees growing in soils deficient in zinc and copper may be given nutritional sprays containing these elements, to ward off deficiency diseases. Though farmyard manure is most commonly used, in certain places, green manure, leaf mould, sheep manure and groundnut cake are also applied [Katyal & Chadha, *Fertil. News*, 1961, **6**(2), 10 ; Shanker, ibid., 1966, **11**(5), 27 ; Gandhi, loc. cit.].

Pruning—Guava grows into a small tree if left unpruned. To avoid this, a judicious pruning is necessary. By the second year the tree should be pruned for shaping its main framework. Some of the lower branches may be removed to give the tree a clear height of stem, about 2–3 m. from the ground. Three or four good, strong, well grown branches should be selected for the permanent framework and all the other branches arising from the trunk should be pruned away. After the framework has been established, dead, diseased and broken branches and suckers arising from the rootstock should be removed every year. Long rambling branches should be headed back. Generally pruning in fruiting trees is done after harvesting the crop.

Guava trees propagated by grafting or layering have low, horizontally drooping branches, and often produce an enormous number of fruits all along their length. Taking advantage of this, in Maharashtra and Deccan, some sort of forcing of dormant buds in the upright branches of seedling trees is brought about by bending the branches of adjacent trees and tying them up into arches. This method has been found to increase fruit production to a great extent (Shanker, loc. cit.; Gandhi, loc. cit.).

In tropical regions if irrigation is given, the guava may bear fruits more or less throughout the year; but in India there are generally two or three well defined periods. In North India, the main crop comes from the flowers of the rainy season and ripens in winter. Flowers appearing in the early spring give rise to a second crop, ripening in the rainy season. The fruits of rainy season crop, however, are poor in quality, insipid and watery: the yield is also very poor. To avoid this crop, the irrigation is withheld at the time of bloom, viz. April to May. In Maharashtra, Madras and Andhra, there is sometimes a third crop with flowers appearing in October. This is purely a chance crop depending on the monsoon (Balasubrahmanyam, *Indian J. Hort.*, 1959, **16,** 69; Cheema *et al.*, 254; Hayes, 287; Dasarathy, *Madras agric. J.*, 1951, **38,** 521).

Diseases and Pests—Wilt is the most serious disease of guava. It is caused by *Fusarium oxysporum* f. *psidii* Prasad and is reported to occur in soils with *p*H above 7.5, being more severe on more alkaline soils. In the eastern parts of Uttar Pradesh and in Bihar, wilt has taken a serious form. Symptoms appear during the rainy season after the fungus has been present in the trees for several months. The leaves turn yellow, curl, dry and then are shed from the top. The affected branches dry successively and ultimately the whole tree dries up. The infection is spread through the contact of the diseased roots with those of healthy plants. No definite control measure is reported. Evolving of wilt-resistant stocks may prove effective against the disease. Injection of 8-quinolinone sulphate is reported to delay the development of symptoms in diseased plants. Wilt (seedling blight) is also reported to be caused by *Rhizoctonia bataticola* Taub. and can be easily controlled by sprays of 0.2 per cent Flit 406 [Prasad *et al*., *Nature, Lond.*, 1952, **169,** 753; Shanker, loc. cit.; Edwards, *Allahabad Fmr*, 1960, **34**(5), 289; Tandon, *Hort. Advance*, 1962, **6,** 89; Naithani & Srivastava, *Allahabad Fmr*, 1965, **39**(2), 65; Chattopadhyay & Sen Gupta, *Indian J. Hort.*, 1956, **12,** 78].

Another disease to which guava succumbs is the canker which is reported to be caused by the fungi, *Glomerella psidii* (Del.) Sheld., *Colletotrichum psidii* Curzi and *Pestalotiopsis psidii* (Pat.) Venkatakrishniah. The characteristic symptom of this disease is the development of spots and malformations on the young, green and mature fruits. Small, circular spots appear on buds, calyx and leaves. The spots enlarge, turn black or brown and coalesce. In severe cases raised cankerous spots develop in great numbers and the fruit breaks open to expose the seeds. The infected fruits remain undeveloped, become hard and mummified. Three or four sprayings with one per cent Bordeaux mixture or with lime sulphur solution (1:25) done at 15 days' interval in the early stages of infection controls the spread of the disease (Venkatakrishniah, *Proc. Indian Acad. Sci.*, 1952, **36B,** 129; *Curr. Sci.*, 1954, **23,** 164; Patel *et al.*, *Indian Phytopath.*, 1950, **3,** 165; Mathur, *Indian J. Hort.*, 1956, **13,** 26).

Guava is also attacked by *Physalospora psidii* Stevens & Pierce, causing bark canker. The bark dries up, cracks and ultimately sheds resulting in the death of affected branches (Patel *et al.*, loc. cit.; Mathur, loc. cit.).

The bark-eating caterpillar *Indarbela quadrinotata* Wlk., which is also common on mango and citrus, causes severe damage to old and neglected guava orchards. It eats away the bark of the tree by making holes in the branches and shoots. Hand-picking of eggs and caterpillars is recommended as control measure. Fumigating the galleries with petrol or carbon disulphide controls the pest. Formalin (4%) or paradichlorobenzene can also be used to kill the caterpillar [*Plant Prot. Bull., New Delhi*, 1959,

11(1-4), 21; Wlth India—Raw Materials, V, 199; David & David, *Allahabad Fmr*, 1963, **37**(6), 33].

The most serious pest of guava is the mealy scale *Pulvinaria psidii* Mask. The affected plants are covered with a sooty mould or greyish meal. It can be controlled by two sprays of fish-oil rosin soap at the rate of 0.5 kg. to 36.0 litres (8 gallons) of water or with crude oil emulsion at the rate of 6.75 kg. to 450 litres (100 gallons) of water. Spraying with 0.03 per cent Diazinon at 4.5–9.0 litres (1-2 gallons) per tree is also recommended. Mealy bug is also quite a prominent pest in some parts of India. Maggots of the fruit fly *Dacus ferrugineus* Fabr. and *D. zonatus* Saund. cause severe damage to guava crop in rainy season. Removal of affected fruits, and spraying the trees with BHC or Diazinon are the control methods suggested. Birds and bats also cause serious damage to the fruits [Wlth India Raw Materials, V, 200; Ansari, *Punjab Fr. J.*, 1947, **11**, 175; *Plant Prot. Bull., New Delhi*, 1959, **11**(1-4), 21; Hayes, 295; Ibrahim, *Madras agric. J.*, 1943, **31**, 279; Rahman *et al.*, *Indian J. agric. Sci.*, 1941, **11**, 816].

Some of the partial angiospermous parasites, viz. *Dendrophthoe falcata* (Linn. f.) Ettings, cause severe damage to guava plants, especially in old and neglected orchards. These can be easily killed by a single spray of diesel oil emulsion prepared in soap water. In the plains of Uttar Pradesh 30–35 per cent diesel oil emulsion has been found effective in summer (April to June) and 50-55 per cent in winter (November to January) (Bahadur Singh, *Hort. Advance*, 1958, **2**, 68).

A deficiency disease reported in guava is characterized by small leaves, interveinal leaf chlorosis, suppression of growth and dieback of growing branches accompanied by cracking of fruits. One or two foliage sprayings with a solution of zinc sulphate, hydrated lime and water is beneficial against the disease (Ray Chaudhuri *et al.*, *Indian Phytopath.*, 1961, **14**, 134; Mathur, loc. cit.).

Harvesting and Yield—The guava tree begins to bear small crops from its fourth year. It reaches full maturity and starts bearing large crops in its eighth year and may continue to bear heavily for 30 years or more. It is a very hardy tree, and given good care may flourish for over 50 years.

The guava tree takes nearly 5 months from flowering time to maturation of fruit. Fruits attaining maturity show signs of changing their colour from dark green to yellowish green. This is the right stage for harvesting them for the market. Though the guava acquires the finest eating quality when allowed to turn perfectly yellow and to ripen fully on the tree, it is not advisable to keep it so long on the tree, since it either drops or is eaten away by birds and squirrels. Also, such ripe fruits become soft and over-ripe and unfit for consumption by the time they reach the consumer. The guava fruit does not keep in wholesome condition for more than a couple of days after it is fully ripe (Gandhi, loc. cit.).

Individual fruits, as and when they show a slight change in colour, are plucked while they are still hard and firm. Immediately after plucking, the fruits are graded for different sizes, and the different grades packed separately. Fruits are usually packed in cylindrical bamboo baskets, padded with rice straw or any other soft dry grass. The fruits are lightly arranged in circular rows and alternated with thin layers of straw.

During transit, the fruits turn partially yellow and emit a sweet fragrance. On reaching the destination, they are taken out of the package and stored loose and kept exposed to the air, till they are sold out (Gandhi, loc. cit.).

A seedling tree of 8–10 years and above may bear 400–500 fruits, weighing about 60–80 kg. and a grafted or layered tree of the same age may bear as many as 1,000–2,000 fruits weighing about 180-310 kg. In Allahabad, a yield up to 35 tonnes per hectare has been reported (Naik, 1958, 45; Gandhi, loc. cit.).

Storage—Guava is a highly perishable fruit and must be sold out soon after its arrival in the market. It is possible to keep ripe but firm guavas in good condition for about a week in cold storage at 11°, but they tend to lose their lustre and to deteriorate once they are removed from the storage. Hence, cold storage of guavas is not recommended. *Allahabad Safeda* type of guavas can be stored for 4 weeks at a temperature of 9–10° and R.H. of 85–90 per cent. Bigger fruits should be chosen for cold storage in preference to smaller ones. The approximate post-storage life at 25–30° is three days. Storage life of the fruits coated with 3 per cent wax emulsion (carnauba-paraffin or carnauba resin emulsion), can be extended by 80 per cent at room temperature (22–28°) and by 50 per cent at low temperature (8–10°) (Mathur, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4**, 215; Singh & Mathur, *Indian J. Hort.*, 1954, **11**, 1; Srivastava *et al.*, *Food Sci.*, 1962, **11**, 244).

Utilization and Chemical Composition

The guava is a sweet, juicy and highly flavoured fruit, eaten mostly as fresh fruit. It may also be canned, preserved, spiced or made into jam, butter, marmalades, pies, ketchups and chutneys. In Hawaii, guava juice is said to make an excellent substitute for orange or tomato juice in child feeding (Ruehle, *Econ. Bot.*, 1948, **2,** 306; Siddiqui & Farooqui, *Pakist. J. sci. Res.*, 1959, **11,** 29).

Guava is one of the richest natural sources of vitamin C and contains 4 to 10 times more of this vitamin than the citrus fruits. It also contains considerable amount of pectin. As compared to mango and apricot, guava is deficient in vitamin A but superior in most of the other major nutrients. A typical analysis of Indian guava is as follows: moisture, 81.7; protein, 0.9; fat, 0.3; fibre, 5.2; other carbohydrates, 11.2; and mineral matter, 0.7%; calcium, 10; magnesium, 8; oxalic acid, 14; phosphorus, 28; iron, 1.4; sodium, 5.5; potassium, 91; copper, 0.3; sulphur, 14; chlorine, 4; thiamine, 0.03; riboflavin, 0.03; nicotinic acid, 0.4; and vitamin C, 212 mg./100 g.; vitamin A, nil. Phytin phosphorus constitutes 54 per cent of the total phosphorus. Iron is present entirely in ionisable form (Siddiqui & Farooqui, loc. cit.; Nutritive Value of Indian Foods, 68, 103, 133).

Vitamin C content of guava shows wide variations, and ranges from 100 to as high as 1,000 mg./100 g. It is highest in the skin and in the flesh next to it and decreases in the inner portions of the fruit. Also maximum ascorbic acid oxidase activity is localized in the core of the fruit. The vitamin C value increases with maturity and reaches its maximum when the fruit is fully mature, but declines when the fruit becomes over-ripe and soft. Some observers have found the pink-fleshed types to be richer in vitamin C than the white-fleshed ones, but others have recorded higher values in the white-fleshed types. The vitamin C potency is probably a type characteristic not associated with colour. Among the important types grown in Uttar Pradesh, *Chittidar* has been found to be the richest in vitamin C; its vitamin C value at different stages of growth was as follows: immature, 244.5; ripe, 304.5; and over-ripe, 222.5 mg./100 g. Guava is reported to contain a bound form of the vitamin, ascorbigen, amounting to about 15 per cent of the total vitamin C content [*Food Sci.*, 1962, **11,** 381; Siddiqui & Farooqui, loc. cit.; Jain *et al.*, *Chem. Age, India*, 1954, Ser. 9, 88; Srivastava & Srivastava, *Punjab hort. J.*, 1965, **5**(1), 12; *Chem. Abstr.*, 1949, **43,** 4729; Akmal *et al.*, *Allahabad Fmr*, 1957, **31**(1), 23; Teaotia *et al.*, *Indian Agriculturist*, 1962, **6,** 47; Bose & Guha, *Ann. Biochem.*, 1963, **23,** 149].

Citric is the major acid in guava, tartaric and *l*-malic acids being present in smaller amounts. Carbohydrates occur chiefly in the form of sugars of which reducing sugars form the major part. Analysis of 8 types of guava from Uttar Pradesh gave the following values: acidity (as citric), 0.2–0.5; reducing sugars, 2.4–6.1; non-reducing sugars, 0.5–5.3; tannin, 0.1–0.4; starch, 0.6–0.8; and pectin, 0.3–1.6%. Tannin content is high at the early stages of growth, and gradually decreases to a low value at the fully mature stage. There is also a drop in acidity and acid-soluble pectin as the fruit reaches maturity. Guava pectin consists of *d*-galacturonic acid (72%), *d*-galactose (12%), and *l*-arabinose (4.4%). In one sample of fully developed yellow fruits, the total pectin (methoxyl content, 10.4%) was made up of: water-soluble pectin, 0.2; oxalate-soluble pectin, 0.1; and acid-soluble pectin, 0.9%. Though guava pectin is of good jelly grade, it is not found to be economical to produce pectin from the fruit on a large scale [*Indian hort. Abstr.*, 1954, **4**(4), 6; Teaotia *et al.*, loc. cit.; *Annu. Rep. cent. Fd technol. Res. Inst., Mysore*, 1961–62, 12; Pruthi *et al.*, *Def. Sci. J.*, 1960, **10,** 45; *Sci. & Cult.*, 1960, **26,** 34; *Food Sci.*, 1962, **11,** 344].

Guava is poor in carotenoid pigments. The pulp of *Allahabad Safeda* type (white-fleshed) contained β-carotene and xanthophyll in equal proportions (total carotenoids, 0.2 μg./g.). The pink-fleshed types are generally considered to be a better source of β-carotene. However, a pink-fleshed type from Mysore contained mostly lycopene and very little β-carotene. Leucocyanidin and ellagic acid are the polyphenolic compounds identified in the ripe fruit; the former is obtained in highest yields from unripe fruits, while in the ripe ones it is more concentrated in the skin and seeds. The red skin of apple guava type is found to contain a cyanidin diglucoside, probably mecocyanin. Quercetin, its 3-arabopyranoside guaijaverin, gallic acid, and arabinose ester of ellagic acid, besides leucocyanidin, have been isolated from the unripe fruit (Sadana & Bashir Ahmed, *J. sci. industr. Res.*, 1949, **8B,** 35; *Food Sci.*, 1962, **11,** 12; Seshadri & Vasishta, *Curr. Sci.*, 1964, **33,** 334).

The seeds constitute 6–12 per cent of the whole fruit and contain up to 14 per cent of an orange-yellow, aromatic, fatty oil. Analysis of the seeds (from the Philippines) gave: moisture, 10.3; pro-

teins, 15.2; fat, 14.3; tannins, 1.4; glucose, 0.1; starch, 13.2; fibre, 42.4; and ash, 3.0%. Ripe seeds collected from Varanasi during the rainy season, gave 5 per cent of a fatty oil with the following constants: $d^{20°}$, 0.9365; $n_D^{25°}$, 1.4687; sap. val., 198.7; acid val., 6.4; iod. val., 96.4; R.M. val., 0.35; Polenske val., 0.1; and unsapon. matter, 0.68%. The fatty acid composition was as follows: saturated acids, 16.0; oleic, 55.8; linoleic, 27.8; and linolenic, 0.4%. Saturated acids present are myristic, palmitic and stearic. Seeds from the Philippine and Japanese guavas yielded oils with iodine values as high as 140 (Eckey, 706; Thorpe, V, 154; Varma *et al.*, *Fettchem. Umsch.*, 1936, **43**, 8; Subrahmanyam & Acharya, *J. Sci. Fd Agric.*, 1957, **8**, 657).

GUAVA PRODUCTS

Guava is used in the preparation of guava cheese, canned guava and guava jelly. Processes have also been developed for drying guavas as such and as pulp in the form of sheets, and also for the preparation of products such as guava juice and juice powder, guava concentrate, and guava nectar (*Food Sci.*, 1962, **11**, 381; Jain & Hirway, *Agric. Res.*, 1965, **5**, 258).

Guava Cheese—Guava cheese is prepared from ripe and firm fruits. The fruits are washed and cut into small pieces, boiled in water and the pulp after straining to remove seeds and peels, is mixed with sugar and butter and heated until the mass becomes sufficiently thick. Citric acid, common salt and colouring matter are added. The whole product is allowed to set and then cut into pieces of attractive shape. It is wrapped in butter paper and stored in a dry clean place. A cold process has also been developed for the preparation of guava cheese using the pulp along with the seeds and peelings (*Food Sci.*, 1957, **6**, 212; Girdhari Lal *et al.*, 258).

Guava Jelly—For the preparation of guava jelly, healthy, and rather tart fruits are preferred; they are washed, cut into small pieces, and after the addition of citric acid, boiled in water for about half an hour. The juice is pressed out with a muslin cloth, and examined for the degree of richness in pectin content. It is cooked with an equal quantity of sugar till the resulting jelly boils at 105° [*Indian hort. Abstr.*, 1953, **3**(12), 8].

Canned Guava—Fully ripe and firm fruits preferably with white flesh and few seeds are chosen for canning. The fruits are peeled with a knife, cut into halves, and the seeds present are scooped out. The peeled cored fruits are kept immersed in 1–2 per cent common salt solution to prevent browning, and canned in hot sugar syrup containing citric acid. Canned guavas often have a taste and aroma better than those of the fresh fruits. Loss of ascorbic acid during canning amounts to 19.4 per cent. During storage at room temperature (25–30°) for 6, 12, and 24 months, the ascorbic acid losses have been recorded to be 10.0, 18.3, and 39.5 per cent, respectively. Effects of blanching and canning by different procedures on ascorbic acid content of the fruits have also been studied (Girdhari Lal *et al.*, 65; *Food Sci. Abstr.*, 1955, **27**, 666; Dhopeshwarkar & Magar, *J. sci. industr. Res.*, 1952, **11A**, 264; 1954, **13B**, 49; 1955, **14C**, 27).

Guava Nectar—Pink-fleshed fruits are found particularly suitable for the preparation of guava nectar. The inner pulp is sieved and blended with sugar syrup of 15° Brix and 0.25 per cent acidity, when a nectar type of beverage, having a delicious taste and aroma, is obtained. The yield of guava juice is 65–80 per cent on the weight of the whole fruit. The juice can be processed into a powder of high quality. The products are likely to find application in syrups, aerated water industry and large scale feeding programmes. Guava paste can be prepared by boiling down the juice until it forms a gel on cooling (*Food Sci.*, 1962, **11**, 381; von Loesecke, 1942, 81; Jain & Borkar, *Agric. Res.*, 1964, **4**, 214).

LEAVES

The leaves of *P. guajava* contain catechol and pyrogallol types of tannins (8–15%). Dry mature leaves from Uttar Pradesh contain 13.9 per cent of tannins and 9.0 per cent of non-tannins. The leaves can be used for tanning in sole and heavy leather tannage, and also probably for upper leathers when blended with other suitable tanning materials. Leathers tanned with guava leaves alone or a blend of leaves and myrobalan (3:1) did not crack even after six months, and were of fine, smooth and tight grain (Pande & Kumar, *J. Indian Leath. Technol. Ass.*, 1960, **8**, 139; Wehmer, II, 829).

The leaves contain a yellowish green or yellowish red essential oil having a pleasant agreeable odour. Leaves of the red-fleshed type from Bangalore gave 0.26 per cent of the oil and those of the white-fleshed type from Allahabad gave 0.31 per cent; the properties of the two oils were, respectively: $d_4^{26°}$, 0.9001, 0.9102; n, 1.4882 (at 25°), 1.487 (at 23°); $[\alpha]_D$, +5.5°, −13.1°; acid val., 1.1, ...; and ester val., 12.3, 4.7. The essential oil contains *d*- and *dl*-limonenes, β-caryophyllene, a bicyclic sesquiterpene

alcohol, and a tertiary sesquiterpene alcohol. Oil of guava leaves is aromatic and is useful as a flavouring agent. It inhibits the growth of *Escherichia coli*, *Bacillus subtilis* and *Micrococcus pyogenes* var. *aureus* (Bhati, *Perfum. essent. Oil Rec.*, 1953, **44,** 46; Bhati *et al.*, ibid., 1953, **44,** 274; Bhati, ibid., 1967, **58,** 707; *Philipp. Abstr.*, No. 2, 1961, 24).

Leaves contain wax, resins, sugars, carotene, vitamins B_1, B_2, and B_6, niacin, and vitamin C. The presence of the following constituents in leaves from different sources has been reported by various observers: β-sitosterol, quercetin and its arabinosides, guaijaverin and avicularin, a mixture of triterpenoid acids, viz. ursolic, oleanolic, cratagolic and guaijavolic ($C_{30}H_{48}O_{4}$, m.p. 306–08°), a new triterpene sapogenin (m.p. 153–55°), leucocyanidin, and ellagic acid and its 4-gentiobioside designated amritoside ($C_{26}H_{26}O_{18}$, m.p. 248–50° decomp.) (Arthur & Hui, *J. chem. Soc.*, 1954, 2782, 1403; Soliman & Farid, ibid., 1952, 134; El Khadme & Mohammed, ibid., 1958, 3320; Varshney & Shamsuddin, *Indian J. Chem.*, 1964, **2,** 377; Seshadri & Vasishta, *Phytochemistry*, 1965, **4,** 989).

BARK

The bark of the guava tree contains considerable amount of tannins (11 27%), and is used for tanning and dyeing purposes. Leucocyanidin, luteic acid, ellagic acid and amritoside have been isolated from the stem bark [Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 154; Hooper, *Agric. Ledger*, No. 1, 1902, 43; Seshadri & Vasishta, *Phytochemistry*, 1965, **4,** 317].

WOOD

The wood is smooth and works well. It is used for wood-engraving and for spear-handles, instruments and for lac-turnery (Gamble, 355).

MEDICINAL USES

The guava plant as well as its fruits are of considerable medicinal importance. Extracts of leaves, flowers, and fruits were found active against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. Extracts of the fruits were moderately active against enteric pathogens like *Salmonella typhosa* and *Shigella antidysenteriae* BII. The guava leaves are used for wounds, ulcers and as an astringent for bowels. The young leaves are used as a tonic in the diseases of the digestive functions. The decoction of leaves has been used in cholera with some success in arresting vomiting and diarrhoea. An infusion of the leaves and roots is a popular astringent drink in Ghana. A decoction of the young leaves and shoots is prescribed in febrifuge and antispasmodic baths. Infusion of leaves is used in cerebral affections, nephritis and cochexia. The pounded leaves are locally applied in rheumatism, and an extract is used in epilepsy and chorea; the tincture is rubbed over the spine of children suffering from convulsions. A decoction of the leaves when gargled relieves toothache and gum boils (Kirt. & Basu, II, 1047; Bushnell *et al.*, *Pacif. Sci.*, 1950, **4,** 167; Rao, *Andhra agric. J.*, 1954, **1,** 368).

The bark is valued for its astringent properties, and has been employed in diarrhoea in children. It is generally administered in the form of a decoction. The bark is tonic and the ash caustic.

The flowers are said to cool the body and are used in bronchitis. They are also applied to eye sores. The fruit is tonic, cooling and laxative. It is good in colic and for bleeding gums. The fruit and its conserve are astringent and used in diarrhoea and dysentery (Kirt. & Basu, II, 1046–47).

P. guineense Sw. syn. *P. molle* Bertol.; *P. araca* Raddi

GUINEA GUAVA

McVaugh, *Publ. Field Mus. nat. Hist., Bot. Ser.*, 1958, **13,** pt 4, No. 2, 796; Deb, *Bull. bot. Surv. India*, 1961, **3**(8), 87.

An undershrub, or rarely a small, evergreen, pubescent-villous tree, up to 7 m. high, native of tropical America and New Guinea and cultivated in other tropical countries. It is reported to be grown in experimental gardens. At Agartala (Tripura), it has become naturalized and is found growing wild. Leaves opposite, 6–15 cm. × 4 8 cm., ovate, oblong or elliptic, entire or distantly serrulate, glabrous above, ferruginous tomentose below; inflorescence an axillary dichasium, 3- or 1-flowered in some cases, flowers white; fruit a berry, pyriform, about 2 cm. in diam., containing many seeds.

The Guinea Guava bears profusely, but the fruits are small and thick-skinned. It is also very hardy and has long flowering duration. *P. guineense* has been crossed with *P. guajava*. When the latter is used as the female parent, the cross has been found to be successful. The hybrids are dwarf, hardy and prolific bearing (Seth, *Hort. Advance*, 1962, **6,** 173).

The fruit is edible and has a delicate acid taste (McVaugh, loc. cit.).

Psilomelane — *see* **Manganese Ores**

PSILOTUM Sw. (*Psilotaceae*)

Prain, II, 1269; Fl. W. trop. Africa, suppl., 17.

A very small genus of highly variable herbs, distributed in the tropical and sub-tropical regions of the world. One species occurs in India.

P. nudum Beauv. syn. *P. triquetrum* Sw. is a small terrestrial or epiphytic, tufted, dichotomously branched, perennial herb, found mostly in rocky crevices in moist and shady places throughout India, ascending up to an altitude of about 2,000 m., and also in the Andamans. The herb is scarce, although it has been recorded from a number of localities. Since the plant has a close resemblance to the Devonian Psilophytes, it may be called a living fossil.

In Hawaii, the herb is used to prepare a kind of tea which is administered to children suffering from thrush; it is also used as a purgative. The oily spores are given to infants to arrest diarrhoea. The juice of the herb showed antibacterial activity against *Micrococcus pyogenes* and *Pseudomonas aeruginosa* (Information from the Botanical Survey of India; Degener, 20; Bushnell *et al., Pacif. Sci.*, 1950, **4**, 170, 177).

The shoots yield a phenolic glucoside, psilotin [6-(4′-β-D-glucopyranosyl oxyphenyl)-5, 6-dihydro-2-oxo-2H-pyran]. The plant contains biflavones, apigenin, acacetin, genkwanin, amentoflavone and hinokiflavone (McInnes *et al., Tetrahedron*, 1965, **21**, 2939; Voirin & Lebrreton, *C.R. Acad. Sci., Paris, Ser. D*, 1966, **262**, 707).

PSOPHOCARPUS DC. (*Leguminosae; Papilionaceae*)

A small genus of climbing plants with tuberous roots, native to Africa. One species is cultivated in India for its pods, used as vegetable.

P. tetragonolobus DC. GOA BEAN

Fl. Br. Ind., II, 21 Brown, 1941, II, 160–62, Fig. 72.

BENG.—*Chara-koni-sem, lakar-sem*; TAM.—*Morisuavarai*; KAN.—*Shambe kayi*.

BOMBAY—*Chavdhari ghevda*.

A perennial climber with tuberous roots cultivated in India, Burma and some other South-East Asian countries for its edible pods and tuberous roots. Stem weak, twining; leaves 3-foliolate with broad ovate leaflets, 7.5–15 cm. long; flowers large, light blue, in lax racemes; pods 4-angled, 15–22 cm. long, 2–3 cm. broad, with each angle continued into a much crisped and toothed papery wing 3–6 mm. broad; seeds nearly globular, c. 6 mm. across, smooth.

The Goa bean is thought by some to be native either to India or to Mauritius, but others think it is more likely to have originated in the African region, where all the other four or five species of this genus are found wild. Several varieties are found, some with white flowers and others with bluish flowers. Among the plants grown in India, there are some with yellow-brown seeds and some with very dark brown seeds (Burkill, *Agric. Ledger*, 1906, **13**, 51; Burkill, II, 1818; de Sornay, 171).

The Goa bean prefers comparatively warm and humid regions and thrives well in the damper parts of India. It is said to be successfully cultivated in Deccan, particularly in Mysore and Maharashtra States; it is also grown in Bengal and Madras. The seeds are sown early in the rains and the vines may be supported on a wall or trellis. The plants flower in a couple of months and continue to grow during the greater part of the year, except during the dry warm months. Where the plants are raised for their tubers on a field scale, as in Burma, they are left to spread on the ground. Some types, like the ones grown in

FIG. 105—PSOPHOCARPUS TETRAGONOLOBUS—PODS

India are, however, tuberless (Burkill, *Agric. Ledger*, 1906, **13,** 51 ; de Sornay, 171 ; Hector, II, 681).

The Goa bean can be grown as a perennial, but better results are said to be obtained by planting afresh every season. The young pods are harvested promptly before they mature. Each vine yields about 25 pods every 5 or 6 days and productivity continues if the vines are liberally manured every 2 or 3 weeks. The yield of tubers is said to vary from 2.5 to 6 tonnes per hectare in the different regions of Burma. Observations made in Nigeria and Malaya are said to show that the Goa bean exceeds in nodulation most of the other species of leguminous green crops tried, the calculated weight of the nodules amounting to as much as 0.75 tonnes per hectare. In certain areas of Burma, the sugarcane crop following a crop of Goa beans is said to yield half as much more than usual. Goa bean is said to be well worthy of trials to assess its value as green manure, cover crop, fodder crop or restorative fallow crop, particularly in the wet tropics (Masefield, *Emp. J. exp. Agric.*, 1957, **25,** 139 ; *Trop. Agriculture, Trin.*, 1961, **38,** 225).

The young and tender pods are succulent and sweet and are eaten either raw or cooked. They contain appreciable amounts of calcium, iron, thiamine and ascorbic acid. Mature pods become tough and fibrous. Analysis of edible portion of tender pods (from the Philippines) gave the following values: moisture, 90.4 ; protein, 2.9 ; fat, 0.2 ; carbohydrates, 5.8 ; fibre, 1.3 ; and ash, 0.7% ; calcium, 63 ; phosphorus, 37 ; iron, 0.3 ; sodium, 3.1 ; potassium, 205 ; thiamine, 0.24 ; riboflavin, 0.09 ; nicotinic acid, 1.2 ; and ascorbic acid, 19 mg./100 g. ; vitamin A, 595 I.U./100 g. Non-protein nitrogen accounts for 44.2 per cent of the total nitrogen in the vegetable. The free amino acids present are: serine, aspartic acid, glycine, glutamic acid, alanine, tyrosine, and all the essential amino acids except histidine and methionine (Mensier, 476 ; Brown, 1941, II, 161 ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 28 ; Kulkarni & Sohonie, *Indian J. med. Res.*, 1956, **44,** 511).

In Java, the seeds are eaten after roasting. They contain: moisture, 8.5 ; protein, 41.9 ; fat, 13.1 ; carbohydrates, 31.2 ; and ash, 5.3%. The seeds are reported to be somewhat indigestible : dried seeds cook with difficulty. They contain a trypsin inhibitor which is not affected by heating in boiling water and is partially destroyed (to the extent of 61%) by autoclaving. The seed oil is similar to soybean oil and can be used for cooking and for soap making and the cake can be used as human food as well as stockfeed. Extracts of the seeds showed a non-specific agglutinating activity with the different groups of human red blood cells (Burkill, II, 1819-20 ; Padilla & Soliven, *Philipp. Agric.*, 1933, **22,** 408 ; Sohonie & Bhandarkar, *J. sci. industr. Res.*, 1954, **13B,** 500 ; *Chem. Abstr.*, 1962, **57,** 2748 ; Schertz *et al., Econ. Bot.*, 1960, **14,** 232).

In Burma, the tuberous roots are eaten as a delicacy and there is said to be a large trade in the roots. They are smaller than those of *Pachyrrhizus* with which they are sometimes confused. The tuberous roots swell early and by the time fruits are ripe they are stringy and insipid. They have a fairly agreeable flavour when boiled. They are difficult to cook thoroughly because of their hardness. Dried roots contain: moisture, 9.0 ; protein, 24.6 ; fat, 1.0 ; carbohydrates, 56.1 ; fibre, 5.4 ; and ash, 3.9%. The starch grains of the tubers vary in size and shape, the longer grains predominating. The young leaves are also eaten as a vegetable, raw or steamed. Flowers are eaten or added to various dishes to colour them blue (de Sornay, 174, 255 ; Burkill, *Agric. Ledger*, 1906, **13,** 51 ; Burkill, II, 1819 ; Degener, *J. N. Y. bot. Gdn*, 1945, **46,** 110).

Stems and leaves contain appreciable amounts of vitamins A and C and are used as green fodder. Their nutritive value is as follows: moisture, 78.9 ; protein, 6.3 ; dig. protein, 4.8 ; fat, 1.0 ; carbohydrates, 7.9 ; fibre, 4.1 ; ash, 1.8 ; calcium (CaO), 0.37 ; and phosphorus (P_2O_5), 0.12%. Hydrocyanic acid has been reported in the stems (Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 15, 67, 76, 82 ; Quisumbing, 1035).

P. palustris Desv. syn. *P. longepedunculatus* Hassk., a native of tropical Africa, is in most respects similar to the preceding species and is said to be cultivated in parts of the tropics for its edible pods and tuberous roots. Trials in Ceylon are said to have shown that it is of use as a ground cover for perennial crops and as a component of pastures. In Indonesia, the ripe seeds are reported to be used in the same way as those of *P. tetragonolobus* (Burkill, II, 1818–19 ; Dalziel, 256 ; Paul, *Trop. Agriculturist*, 1951, **107,** 225 ; 1953, **109,** 27).

PSORALEA Linn. (*Leguminosae ; Papilionaceae*)

A large genus of herbs, shrubs or undershrubs distributed in tropical and sub-tropical regions of the world. Four species are found in India of which one is exotic.

P. corylifolia Linn.

D.E.P., VI(1), 353; III, 418; Fl. Br. Ind., II, 103; Kirt. & Basu, Pl. 300A.

SANS.—*Bakuchi, kushthanashini, sugandhakantak*; HINDI—*Babchi, bavanchi, bukchi*; BENG.—*Bavachi, kakuch, latakasturi*; MAR.—*Babachi, bavachya*; GUJ.—*Babchi, bavchi*; TEL.—*Baavanchalu, bapunga, bawuchee*; TAM.—*Kaarboka arisi, karporgam*; KAN.—*Bavanchigida, karbekhiga*; MAL.—*Karpokkari, kaurkoalari*; ORIYA—*Bakuchi*.

An erect annual, 30–180 cm. high, found almost throughout India. Leaves broadly-elliptic, inciso-dentate; flowers yellow or bluish purple, in dense axillary, long-peduncled heads; pods small, 3.5–4.5 mm. × 2.0–3.0 mm., ovoid-oblong, somewhat compressed, mucronate, dark chocolate to almost black; seed one, smooth, adhering to the pericarp.

P. corylifolia is not cultivated on a commercial scale anywhere. It is reported to be grown to some extent in Rajasthan and the eastern districts of Punjab adjoining Uttar Pradesh for its seeds. Seeds of good quality are produced in Rajasthan. The plant

FIG. 106—PSORALEA CORYLIFOLIA—FRUITING BRANCH

grows on any average soil. Seed is sown in March–April in lines, 30 cm. apart, at the rate of 7 kg. per hectare. The plant flowers during rains and seeds mature in November. Under proper care, the plants may continue to grow for 5–7 years (Luthra & Suri, *Spec. Bull., Dep. Agric. Punjab*, 1936, 14; Luthra, *Indian Fmg*, 1950, **11**, 10; Chopra, 1958, 391; Biswas, *J. Asiat. Soc. Sci.*, 1956–57, **22**, 61).

The fruits (seeds)* of *P. corylifolia* consist of a sticky oily pericarp (*c.* 12% of the seed), a hard seed coat and kernel. They are odourless, but on chewing they emit a pungent odour, and have a bitter, unpleasant and acrid taste. The seeds contain an essential oil (0.05%), a nonvolatile terpenoid oil, a dark brown resin (8.6%), a pigment (probably a hydroxyflavone), a monoterpenoid phenol named bakuchiol ($C_{18}H_{24}O$, b.p./0.7 mm. 145–47°), a brown fixed oil (*c.* 10%), raffinose, and coumarin compounds, viz. psoralen (identical with ficusin; $C_{11}H_6O_3$, m.p. 161–62°), *iso*psoralen (identical with angelicin; m.p. 141–42°), psoralidin ($C_{16}H_{11}O_4$, m.p. 315° decomp.), *iso*psoralidin ($C_{16}H_{11}O_4$, m.p. 283–84°), and corylifolin ($C_{17}H_{18}O_3$, m.p. 183°). Later investigations indicated molecular formula of psoralidin to be $C_{20}H_{16}O_5$ (m.p. 290–92° decomp.). Fixed oil of the seeds is viscous, bitter in taste and on keeping deposits psoralen. It contains considerable resin acids (21.5%); stigmasterol is present in the unsaponifiable matter (Seshadri & Venkatarao, *Proc. Indian Acad. Sci.*, 1937, **5A**, 351; I.P.C., 209; Chopra & Chatterjee, *Indian J. med. Res.*, 1927–28, **15**, 49; Mehta *et al.*, *Tetrahedron Lett.*, 1966, 4561; Jois *et al.*, *J. Indian chem. Soc.*, 1933, **10**, 41; Bhattacharji, *J. sci. industr. Res.*, 1961, **20B**, 135; Chakravarti *et al.*, ibid., 1948, **7B**, 24; *Chem. Abstr.*, 1936, **30**, 4855, 7575; Dattagupta *et al.*, *Chem. & Ind.*, 1960, 48; Siddappa & Devi, *Proc. Indian Sci. Congr.*, 1957, pt III, 130; 1956, pt III, 126; Khastgir *et al.*, *Indian J. appl. Chem.*, 1959, **22**, 35).

The seeds are used in indigenous medicine as laxative, aphrodisiac, anthelmintic, diuretic and diaphoretic in febrile conditions. They have been specially recommended in the treatment of leucoderma, leprosy, psoriasis and inflammatory diseases of the skin, and are prescribed both for oral administration and for local external application in the form of a paste or ointment. The use of seeds in the treat-

* The word seeds has been used throughout the article, though botanically they are really indehiscent pods of the plant, the pericarp closely adhering to the seed.

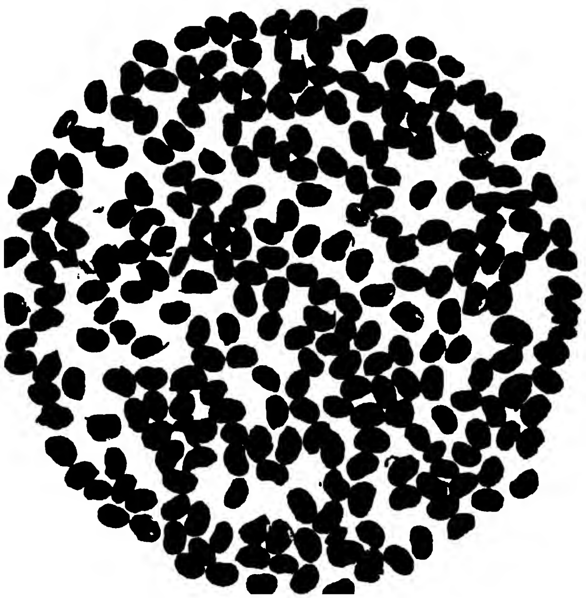


FIG. 107—PSORALEA CORYLIFOLIA—FRUITS

ment of leprosy has been more or less abandoned [Chopra, 1958, 391; Mukerji, *J. sci. industr. Res.*, 1956, **15A**(5), suppl., 1].

Extensive clinical trials carried out in India have shown that the seeds and their various preparations are useful in the treatment of leucoderma of non-syphilitic origin. Psoralen and *iso*psoralen are considered the therapeutically active constituents of the seeds. The drug appears to have a purely local action, with a specific effect on the arterioles of the sub-capillary plexuses which are dilated so that plasma is increased in this area. The skin becomes red and the melanoblasts (pigment-forming cells) are stimulated. In leucoderma, melanoblasts do not function properly and their stimulation by the drug leads them to form and exude pigments which gradually diffuse into the white leucodermic patches. The treatment by this drug has not been effective in the leucoderma of syphilitic group, because in such cases, in all probability melanoblasts are killed, for they are not visible in histological preparations [Chopra, 1958, 391–95; Mukerji & Bhandari, *East. Pharm.*, 1959, **2**(20), 29].

A number of preparations made from the seeds have been tried in numerous cases of leucoderma and other skin diseases. Oral administration of the powdered seeds to the patients has generally resulted in side reactions such as nausea, vomiting, malaise, headache and sometimes purging. External application of the essential oil preparations generally proved to be highly irritant to the skin causing sensitiveness and even blistering. Intradermal injection of the oil, though effective, was normally accompanied by severe pain with tendency to ulceration. Local application of the oleoresinous extract of the seeds has been recommended as a more suitable preparation. The extract is official in Indian Pharmacopoeia as Babchi Ointment or Application of Psoralea. The strength of the oil or oleoresin preparations should be so adjusted as not to allow its action to go beyond the state of redness of the leucodermic patches. The use of these preparations has, however, not resulted in permanent cure; there has been even total failure in some cases (Chopra, 1958, 391–95; Mukerji, loc. cit.; I.P., 60; Panja & Maplestone, *Indian med. Gaz.*, 1940, **75**, 93).

Trials with the active principles, psoralen and *iso*psoralen mixture, given orally, have shown that this treatment has some value which is not obtainable by external application of the oil or the oleoresinous extract. In trials with patients aged below 20 and having leucoderma of recent origin, encouraging results were obtained with the furocoumarin mixture. External application of a liquid preparation made from this mixture was also tried on white patches simultaneously with oral administration. The patches tended to be covered up gradually, and the initial time of response varied between 10 and 30 days. No fresh patches appeared during the course of treatment and relapses were few. Processes for the extraction of psoralen-*iso*psoralen mixture from the seeds have been developed and covered by patents. The furocoumarins are present in the fresh seeds as glycosides of the corresponding coumarinic acids and cannot be fully extracted out directly. Soaking the ground seeds in water for a few days prior to extraction hydrolyses the glycosides thereby releasing the coumarins. Yields of up to 1 per cent of the mixture have been obtained. Psoralen is reported to be more potent than other furocoumarins such as xanthotoxin and bergapten (Mukerji, loc. cit.; Mukerji & Bhandari, loc. cit.; Khastgir *et al.*, *Indian J. appl. Chem.*, 1959, **22**, 82; Rangaswami & Seshadri, *Indian J. Pharm.*, 1943, **5**, 105; Chakravarti *et al.*, loc. cit.; Bhattacharji & Dhar, Indian Pat., No. 59265, 59266 and 61772, 1957; Das Gupta, *Proc. Indian Sci. Congr.*, 1962, pt III, 154; Sen, *J. sci. industr. Res.*, 1963, **22**, 88).

The seed extracts inhibit the growth of *Staphylococcus citreus*, *S. aureus* and *S. albus* including

strains resistant to penicillins. A highly potent anti-staphylococcal fraction has been obtained from the seeds. The seeds possess anthelmintic activity against earthworms, psoralen being the active principle. Psoralen is also toxic to fish. The essential oil shows a selective activity against the skin streptococci and this probably accounts for its use in indigenous medicine for the treatment of skin affections. The oil has a marked action on *Paramecium;* in a dilution of 1 in 10,000, streptococci and *Paramecia* are killed in 10 minutes. It has a distinct stimulant action on voluntary muscles in high dilutions, up to 1 in 100,000. It increases the tone of the uterus and stimulates the intestinal smooth muscles of the experimental animals (Gupta *et al., Bull. reg. Res. Lab., Jammu*, 1962, **1,** 59; Gaind *et al., Indian J. Pharm.*, 1964, **26,** 141; 1965, **27,** 198; Iyengar & Pendse, ibid., 1962, **24,** 289; Chopra, 1958, 392–93).

The seeds are used locally in the preparation of certain types of medicated oils and incense preparations. The root is useful in the caries of teeth. Leaves are used in diarrhoea [Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(2), suppl., 159; Cooke, I, 342; Kirt. & Basu, I, 718].

The seed cake left behind after the removal of the fixed oil is rich in nitrogen (6.7%) and minerals (7.8%) and is stated to be suitable as a feed or manure (Seshadri & Venkatarao, loc. cit.).

The plant is eaten by cattle in Bundelkhand. The seeds are reported to be used as an article of food. The whole plant is a good source of nitrogen for organic manure. Its manurial value is as follows (oven-dry basis): organic matter, 87.77; ash, 11.13; nitrogen, 3.69; calcium (CaO), 3.25; potassium (K_2O), 1.18; and phosphorus (P_2O_5), 0.96% [Santapau, *Rec. bot. Surv. India*, 1953, **16,** 51; Patil, *Poona agric. Coll. Mag.*, 1960–61, **51**(3 & 4), 32].

P. plicata Delile (Punjab—*Bakhtmal*) is a low, much-branched shrub, 30–60 cm. high, with trifoliolate leaves, yellow or pale violet flowers and ellipsoid or oblong-globose, one-seeded pods found in Punjab and Delhi.

Camels are fond of this plant. The leaves contain: crude protein, 9.4; ether extr., 1.5; N-free extr., 41.9; crude fibre, 40.1; mineral matter, 7.2; calcium, 1.9; and phosphorus, 0.2%. The young pods are reported to yield a yellow dye [Singh *et al., Indian J. vet. Sci.*, 1959, **29**(2 & 3), 32; Fl. Delhi, 134].

PSYCHOTRIA Linn. (*Rubiaceae*)

A large genus of shrubs or small trees, rarely herbs, distributed in the tropical and sub-tropical regions of the world. About 45 species occur in India.

P. montana Blume

Fl. Br. Ind., III, 174.

A small evergreen shrub found in the plains of Assam and in Khasi hills. Leaves elliptic or oblong-lanceolate; flowers whitish, in sub-corymbiform cymes: fruits ovoid-oblong, red.

The roots are used in Malaya for poulticing ulcers and swellings and a lotion made of them is used in fever and for enlarged spleen. The roots, leaves and stem show a positive reaction for alkaloids (Burkill, II, 1821: Kiang *et al., J. Pharm., Lond.*, 1961, **13,** 98).

P. sarmentosa Blume

Fl. Br. Ind., III, 165.

A twining shrub, 3 m. high, found in western ghats and west coast from Kanara southwards. Leaves elliptic or elliptic-obovate; flowers greenish, in corymbiform cymes: fruits small, obovoid, white, fleshy.

In Malaya, the plant is used as medicine to expedite child-birth and the leaves are applied as poultice for sores (Burkill, II, 1822).

P. viridiflora Reinw. syn. *P. jackii* Hook. f.; *P. calocarpa* Kurz

Fl. Br. Ind., III, 167, 173.

A small evergreen shrub found in Nepal and Sikkim Himalayas, at altitudes of 600–1,200 m., and in North Bengal, Assam, Nagaland, N.E.F.A., Manipur, and Khasi, Aka and Lushai hills. Leaves very variable in size and shape, lanceolate or elliptic-lanceolate, entire or broadly crenate; flowers pink greenish or white, in cymes; fruits ellipsoid or sub-globose, succulent, orange or red.

The leaves are reported to yield a red dye. In Sarawak, old leaves are boiled with water, and when the liquid is sufficiently concentrated, powdered lime is added to it. The cloth is soaked in the liquid for a long time when it is dyed red-brown. The leaves, bark and stem juice are used for skin affections, and against bites of poisonous insects (Burkill, II, 1823).

Psychotria ipecacuanha — *see* **Cephaelis**

Psyllium — *see* **Plantago**

PTERIDIUM Scop. (*Polypodiaceae*)

A genus of ferns distributed in the tropical and temperate zones. The genus is usually regarded as consisting of a single variable species or a group of

closely allied species. It is represented in India by *P. aquilinum*.

P. aquilinum Kuhn syn. *Pteris aquilina* Linn.
BRACKEN, BRAKE

D.E.P., VI(1), 355; Beddome, Indian Ferns, 115; Blatter & d'Almeida, Pl. VII.

TAM.—*Parnai*; MAL.—*Tavi*.

PUNJAB—*Deo, kakei, kakhash, lungar*; LUSHAI—*Katchat*.

A tufted, fast-growing fern, with a stout, creeping rhizome, producing numerous fronds, found growing on exposed grassy lands in the hills throughout India, at altitudes of 600–3,600 m. Fronds mostly tripinnate, the uppermost pinnae simple, usually 0.6–1.8 m. long and 30–90 cm. broad, but may grow up to 3.6 m. in length.

Bracken is an ornamental fern, grown for borders and rockeries and also planted in pots for indoor decoration. It can be propagated through division of rhizomes, or from spores. In some countries, it has become a troublesome weed, and steps have been taken to control it mechanically or by the use of chemicals, particularly sodium chlorate and sodium arsenite [Medsger, 136; Swarup & Sharma, *Indian Hort.*, 1960–61, **5**(4), 17; Nelthorpe, *Quart. J. For.*, 1950, **44**, 18; *Field Crop Abstr.*, 1953, **6**, 57; Muenscher, 1955, 111; Robbins *et al.*, 431; Rose, 56].

In times of scarcity, the rhizomes are boiled or roasted and eaten, or are ground into powder used for making bread. The starch, present in the rhizomes, is bitter; this bitterness can be removed by washing. It is reported that in China and Japan, the starch has long been extracted for medicinal use. Mixed with malt, the rhizomes are used for brewing a kind of beer. They are also employed as a feed for stock, especially pigs. Analysis of meal from the dried rhizomes gave: dry matter, 90.0; protein, 9.5; fat, 1.2; carbohydrates, 51.0; fibre, 20.0; and ash, 8.3%. The rhizomes contain much mucilage, sugars (6.7%), catechol tannin (6.6%), and a bitter glycoside, pteraquilin (m.p. 92°). The presence of a bitter saponin, aqueous dispersion of which is highly toxic to fish, has been reported; it is, however, non-toxic to rabbits. Bracken is reported to be used for tanning certain leathers (Burkill, II, 1823–24; Hedrick, 470; Watt & Breyer-Brandwijk, 1092; Hoppe, 747; Woodman, *Bull. Minist. Agric., Lond.*, No. 124, 1945, 15; *Chem. Abstr.*, 1954, **48**, 8964; 1957, **51**, 6838).

The tender fronds are mucilaginous. They are used as a vegetable, and also employed in soups. On analysis, the fresh fronds show: moisture, 91.3; protein, 1.0; fat, 0.1; N-free extr., 5.6; fibre, 1.4; and mineral matter, 0.6%. The fronds contain 0.98 mg./100 g. of β-carotene. Free amino acids, present in good amounts in the fronds, are valine, alanine, tyrosine, leucine, aspartic acid, glutamic acid and asparagine. The fern, on dry basis, contains iodine, 900 μg./kg. (Hedrick, 470; Medsger, 136; Winton & Winton, II, 179; Deuel, I, 519; Hoppe, 747; *Chem. Abstr.*, 1961, **55**, 19061; Iodine Content of Foods, 126).

The green fronds are used as fodder. Feeding trials on cattle and sheep show that fresh, fairly young, green fronds are reasonably digested and, on dry matter basis, have a nutritive value comparable to that of good quality hay; mature brown fronds are poorly digested. Excessive feeding of the fronds for prolonged periods, particularly if the animals are solely fed on bracken diet, is reported to cause severe poisoning in livestock; the fronds show poisonous effects both in the fresh and in the dried states. The symptoms of bracken poisoning are essentially typical of thiamine deficiency, the afflicted animals responding to thiamine treatment. The deleterious effects of the plants are attributed to the presence of two antithiamine factors: (*i*) a thermolabile enzyme thiaminase; and (*ii*) a thermostable factor comprising flavonoid pigments. The flavonoids isolated from the fresh plant include astragalin (kaempferol-3-glucoside), *iso*quercetrin (quercetin-3-glucoside) and a small amount of rutin (quercetin-3-rhamnoglucoside), all possessing thiamine-decomposing activity. Recent examination of the fronds revealed the presence of prunasine (158 mg./100 g.), a cyanogenic glycoside (Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 93; Watt & Breyer-Brandwijk, 1089; *Chem. Abstr.*, 1954, **48**, 4064, 2179; 1955, **49**, 14826; 1956, **50**, 14185; Kofod & Eyjolsson, *Tetrahedron Lett.*, 1966, 1289).

The dried fronds are employed as packing material; they have been tried as a source of paper pulp. Digestion of the fronds with caustic soda gave pulps in yields of 19–24 per cent. The fronds have also been used for making beer similar to that from the rhizomes (Blatter & d'Almeida, 93; Burkill, II, 1824; *Chem. Abstr.*, 1948, **42**, 9164; Watt & Breyer-Brandwijk, 1092).

Bracken is used as litter for cattle and horses in coffee plantations; the manure, thus formed, is rich in phosphoric acid and potash, and is useful for coffee plants.

The rhizomes are astringent and are useful in diarrhoea and inflammation of the gastric and intestinal mucous membranes. Boiled in oil or hog's fat they are made into an ointment for wounds. The juice of the plant is active against Gram-positive bacteria (Kirt. & Basu, IV, 2742; *Chem. Abstr.*, 1957, **51,** 6838; Caius, *J. Bombay nat. Hist. Soc.*, 1935–36, **38,** 360; Nickell, *Econ. Bot.*, 1959, **13,** 303).

PTERIS Linn. (*Pteridaceae*)

Beddome, Indian Ferns, 105; Fl. Malaya, II, 393, Fig. 231.

A large genus of ferns distributed in the tropics and sub-tropics of the world, extending to the Mediterranean region, South Africa, Tasmania, New Zealand and north to Japan and the United States. About 20 species occur in India and some exotics have been introduced into the gardens as ornamentals.

P. ensiformis Burm. f. is a tufted fern with a slender, creeping or sub-erect rhizome and coriaceous dimorphic fronds, inhabiting the eastern parts of India, and the hills of the northern Andhra Pradesh and northern Kerala, usually at low altitudes. It is a hardy fern and is suitable for growing in pots. It develops variegated leaves under shade (Percy-Lancaster, 357; Chittenden, III, 1707).

The young fronds are steamed and eaten as a flavouring. Their juice is stated to possess astringent properties, and a decoction of the fresh fronds is given in dysentery. The juice of the rhizome is applied to the glandular swellings of the neck (Burkill, II, 1824; Quisumbing, 69).

P. multifida Poir. syn. *P. serrulata* Linn. f., non Forsk. is a small terrestrial fern, native of China and Japan, with tripinnate, dimorphic fronds and small rhizomes, introduced in the Indian gardens. It was recorded from Mussoorie in the western Himalayas as an escape from cultivation.

In China, a tincture or a decoction of the fronds and rhizomes is given in dysentery. It is also said to be a good vermifuge. The toasted fronds and rhizomes are made into a paste with sesame oil and applied to the skin affections of infants (Crevost & Petelot, *Bull. econ. Indoch.*, 1935, **38,** 131).

Pteris aquilina — *see* **Pteridium**

PTERNANDRA Jack (*Melastomataceae*)

Fl. Br. Ind., II, 551.

A small genus of trees and shrubs confined chiefly to the Malaysian region. One species occurs in India.

P. caerulescens Jack is a small evergreen tree with ovate or lanceolate leaves, small (6–8 mm. wide), blue flowers in terminal panicles, and ovoid, blue-violet to black fruits with many seeds, recorded from one of the Nicobar Islands. The wood is light brown and soft to moderately hard. It is used as fuel. In Malacca, the pounded fruits are used for poulticing in orchitis and hydrocele. An extract of seeds is given to stop vomiting (Gamble, 368; Burkill, II, 1825–26).

PTEROCARPUS Jacq. (*Leguminosae; Papilionaceae*)

A genus of trees and woody climbers distributed in the tropics throughout the world. Four species occur in India.

P. dalbergioides Roxb. syn. *P. indicus* Baker non Willd. ANDAMAN PADAUK, ANDAMAN REDWOOD

D.E.P., VI(1), 355 in part; C.P., 907; Fl. Br. Ind., II, 238 in part; Bor, 89.

TEL.—*Yerravegisa*; TAM.—*Vengai*.

ANDAMANS—*Chalangada, da*.

TRADE—*Andaman Redwood, padauk*.

A very large semi-deciduous, or practically evergreen, buttressed tree, up to 45.0 m. in height and 5.5 m. in girth, with usually a clean cylindrical bole up to 15 m. above the buttresses, found only in the Andamans, and sparingly cultivated in West Bengal and South India. Leaves imparipinnate: leaflets 5–9, ovate-lanceolate, narrowed gradually to a point, with prominent nerves beneath; panicles almost terminal, flowers golden yellow; pods orbicular, flat, winged, edge of pod between stipe and style usually concave; seeds 1–2, smooth, shining.

This species was formerly confused with *P. indicus* Willd., and included therein, but differs from that species in several respects. Andaman padauk is found scattered in mixed deciduous or semi-evergreen forests where its chief associates are *Lagerstroemia hypoleuca, Terminalia bialata* Steud., *T. catappa* Linn., *Hopea odorata, Mesua ferrea,* and others. It grows best on well-drained lower slopes of hills and in the broader valleys, generally along the tidal creeks above the mangrove belt. It is usually found in large numbers on soil derived from sedimentaries consisting of sandstones and conglomerates. It grows in its natural habitat under a normal rainfall of 295 cm. with the climate damp for the greater part of the year. It is extremely frost-tender and a light demander (Troup, I, 278–81).

Natural reproduction occurs in openings caused by fellings made at the time the padauk seed is ripe on

F.R.I., Dehra Dun

FIG. 108—PTEROCARPUS DALBERGIOIDES

the tree. It is assisted by removing the undergrowth completely every year for three or four years till the young crop is established. Whole pods are sown for artificial reproduction. The seeds are said to be viable for 8 years. Transplantation of nursery-raised one-year old seedlings or natural seedlings with 1-2 pairs of leaves found underneath older trees is preferred to direct sowing. Germination percentage is about 45 but only half the seedlings survive ultimately. Intercrops of maize and sugarcane can be grown in between the rows of padauk and they help to keep down weeds (Troup, I, 283–86; Ganapathy & Rangarajan, *Indian For.*, 1964, **90**, 758).

The rate of growth of natural padauk trees is rather slow but is fairly high in plantations, the mean annual girth increment being about 2.8 cm. It is one of the species recommended for cultivation in tea estates in the plains and foot-hills of North Bengal and Assam for supply of firewood. It coppices well and this power is retained to a great age. *Fomes fastuosus* Lev. attacks the heartwood of standing trees through bruised buttresses, and causes white pocket rot. A few other fungi also cause white rot of the logs. The tree is also attacked by a large number of beetles or their larvae which bore into felled wood [Troup, I, 286-87; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 99; Sujan Singh *et al.*, *Indian For.*, 1961, **87,** 248; Mathur & Balwant Singh, *Indian For. Bull.*, *N.S.*, No. 171(7), 1959, 78].

The sapwood is grey, narrow, heartwood very variable in colour, through shades of light yellowish pink to usually gorgeous reddish with dark lines, darkening on exposure, dull to lustrous, broadly interlocked-grained, coarse-textured, strong, tough, hard and heavy (sp. gr., 0.714; wt., 721 kg./cu.m.). The wood of the buttresses is usually of excellent colour and beautifully figured and the tree often produces large burrs whose wood is also usually very beautiful. Yellowish or light-coloured wood, known as off-colour padauk, has a lower market value. The timber air-seasons well without warping or splitting. It will dry out fairly quickly, if carefully piled in open stacks under cover or in the shade allowing a good air-circulation through the stacks. It is equally amenable to kiln-seasoning which takes 12–15 days for completion. In addition to initial steaming, it needs at least one intermediate steaming and another towards the end of drying at 55°/100 per cent R.H. for about 1–4 hours. For high class work, the wood is subjected to moisture equalization treatment in a kiln at about 55°/70 per cent R.H. for a day or two. The timber is very durable in the open or under cover, but is liable to attack by *Teredo* in contact with sea water. Graveyard tests have shown a durability of over 23 years (Pearson & Brown, I, 384–87; Troup, I, 277; Trotter, 1944, 153; Limaye & Sen, *Indian For. Rec.*, *N.S.*, *Timb. Mech.*, 1953, **1,** 96, 153; Gamble, 259; Rehman, *Indian For.*, 1953, **79,** 349; Purushotham *et al.*, ibid., 1953, **79,** 49).

The wood is not difficult to saw or machine but due to interlocked-grain it takes more effort to bring it to a good finish. It can, however, be worked to a fine surface: it takes a good polish or wax finish after proper filing. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 105; strength as a beam, 100; stiffness as a beam, 105; suitability as a post, 105; shock-resisting ability, 100; retention of

shape, 100; shear, 115; and hardness, 130 (Pearson & Brown, I, 387; Trotter, 1944, 153; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 58, Sheet No. 17).

Padauk wood is highly valued for ornamental and decorative work, panelling, parquetting, balustrades, Pullman cars, ship cabins and saloons. It is especially suitable for heavy carpentry such as billiard tables, counters, piano cases and musical instruments and high class furniture. It is used in cabinet-work, turnery, tool handles, and for making ornamental hair-brush backs. It is also utilized for making gun carriages and wheels, ammunition boxes, boats, carts, frames of buggies, door frames, beams and pile work. It can be sawn or sliced or peeled in the veneer, and makes an attractive plywood. In the early days of aviation it was used for aircraft propellers, test fans and air screws. It can be used as a substitute for *mahua* (*Madhuca indica*) and *sandan* (*Ougeinia oojeinensis*) for timber bridges (Pearson & Brown, I, 387; Trotter, 1944, 154, 199; Gamble, 258; Sekhar & Bhartari, *Indian For.*, 1964, **90**, 767; Bhattee, ibid., 1966, **92**, 109; Masani & Bajaj, ibid., 1962, **88**, 750; Bhandari, *Def. Sci. J.*, 1964, **14**, 33; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 58; *Comp. Wood*, 1956, **3**, 71; Howard, 435; Limaye, *Indian For. Rec., N.S., Util.*, 1942, **2**, 176).

The wood contains a red pigment, santalin and a yellow flavonoid, santal, both of which also occur in *P. santalinus* (q.v.). The bark and the heartwood contain pterostilbene (3,5′-dimethoxy-4-stilbenol) which is reported to be toxic to the brown rot fungus, *Coniophora cerebella* Pers. The heartwood yields pterocarpin ($C_{17}H_{14}O_5$, m.p. 165°), liquiritigenin (7, 4′-dihydroxyflavanone) and *iso*liquiritigenin (2, 4, 4′-trihydroxychalkone). The last two have also been isolated from the sapwood, along with homopterocarpin ($C_{17}H_{16}O_4$, m.p. 87-88°) (Lal & Dutt, *Proc. nat. Acad. Sci. India*, 1940, **10A**, 73; Sawhney & Seshadri, *J. sci. industr. Res.*, 1956, **15C**, 154; King *et al.*, *J. chem. Soc.*, 1953, 3693).

P. indicus Willd. non Baker MALAY PADAUK, NARRA

D.E.P., VI(1), 355 in part; C.P., 907; Fl. Br. Ind., II, 238 in part; Bor, 89; Foxworthy, *Malay. For. Rec.*, No. 3, 1927, 96.

TEL.—*Yerravegisa*; TAM.—*Vengai.*

A large, buttressed tree, up to 36.0 m. in height and 3.6 m. in girth, believed to be native of Malaysia, introduced and planted to a small extent in the Andamans, West Bengal, Madras and Maharashtra as garden and avenue tree; it is distinguished from *P. dalbergioides* by its ovate leaves rounded to a blunt point and the less prominent veins, the panicles which are almost all axillary, and the convex edge of the pod.

The tree requires a deep well-drained soil and does not thrive on stiff clays. It is said to grow best in a tropical climate with an annual rainfall of over 150 cm. It grows readily from seed or cuttings and the rate of growth is said to be extremely rapid. It is said to be suitable for reafforestation and ornamental planting (Troup, I, 292-94; Foxworthy, *Malay. For. Rec.*, No. 3, 1927, 96).

The wood is said to be moderately hard and heavy (wt., 625 kg./cu.m.) and yellow to red in colour. Wood of some types of this species is said to have a scent similar to that of sandal wood. It can be air-seasoned without difficulty. It should not be used in contact with the ground. It is easy to work and takes a good finish and polish. It is a very good furniture and cabinet wood (Browne, 238; Foxworthy, loc. cit.; Burkill, II, 1830).

The wood is said to be used in the Philippines for preparation of a red dye often used for staining light-coloured woods. It contains red colouring matters narrin and santalin, and angolensin. Narrin is a dark red amorphous powder which yields phloroglucinol and resorcinol on fusion with alkali (Brown, 1941, II, 162; Burkill, II, 1831; Mayer & Cook, 151; Bhrara *et al.*, *Curr. Sci.*, 1964, **33**, 303).

A decoction of the wood is given in dropsy and for stone in the bladder. The bark yields a kino similar to that produced by other species of the genus. The kino is used as an application for sores and a decoction of the bark or the kino is used for thrush and to arrest diarrhoea. The medicinal uses mentioned, however, require further investigation (Quisumbing, 427; Burkill, II, 1830).

The seed is said to be emetic. An infusion of the leaves is said to make a hair-wash. Pounded leaves are used as sternutatory for bilious headache. The very young leaves and fragrant flowers are eaten (Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 30; Burkill, II, 1830).

P. marsupium Roxb. INDIAN KINO TREE, MALABAR KINO TREE

D.E.P., VI(1), 357; C.P., 908; Fl. Br. Ind., II, 239.

HINDI—*Bijasal, bija*; BENG.—*Pitshal*; MAR.—*Dhorbenla, asan, bibla*; GUJ.—*Biyo, hiradakhan*;

TEL.—*Yegi, peddagi*; TAM.—*Vengai*; KAN.—*Honne, bange*; MAL.—*Venga*; ORIYA—*Byasa.*

TRADE—*Bijasal.*

A moderate-sized to large deciduous tree, up to 30.0 m. high and a girth of 2.5 m., with a straight clean bole, found commonly in hilly regions throughout the Deccan Peninsula, and extending to Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar and Orissa. Bark grey, rough, longitudinally fissured and scaly; blaze pink with whitish markings, older trees exuding a blood red gum-resin; leaves imparipinnate; leaflets usually 5–7, oblong; flowers in large panicles, yellowish, fragrant; pods orbicular, flat, winged, up to 5 cm. in diam.; seeds 1–2, convex and bony.

The tree is found in deciduous forests both on undulating and flat ground and grows on a variety of formations, provided the drainage is good. It prefers a soil with a fair proportion of sand, though it is often found on red loam with a certain amount of clay. The normal rainfall in its natural habitat ranges from 75 to 200 cm., but it attains its largest size in parts of Mysore and Kerala, where the rainfall is even higher. It is a moderate light demander, and the young seedlings are frost-tender. It coppices fairly well, but is found to pollard better; it produces root suckers sparingly. It is planted as a shade tree in coffee estates in South India and is recommended for planting in tea estates of West Bengal and Assam (Troup, I, 268, 270; *Indian Coffee*, 1955, **19**, 37; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 100).

FIG. 109—PTEROCARPUS MARSUPIUM—FLOWERING AND FRUITING BRANCH

Natural reproduction is through seeds: the early development of seedlings is favoured by shelter from the sun and a loose soil clear of weeds. Seedlings may show little stem development or may die back annually for several years but ultimately shoot up after they have developed a long stout tap root. Measures stimulating natural reproduction are exclusion of fire and grazing, hoeing the soil where seed-bearers are present, and gradually freeing the young plants from the overhead cover (Troup, I, 270).

Artificial reproduction is through seeds. Whole pods are sown and germination can be hastened by cutting across their ends and then soaking them in water for a few days prior to sowing. Stump planting of one-year old plants raised in the nursery is said to give good results. Seedlings may also be raised in bamboo baskets for planting out. Direct sowings are also successful. Plantations are worked either by selection fellings or by coppice system with or without standards. The rate of growth is fairly rapid with a mean annual girth increment of up to about 3.8 cm. The tree is attacked by a number of insects, mostly defoliators, and some fungi which cause rotting of the wood [Troup, I, 270–71; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 79; Bagchee & Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 288].

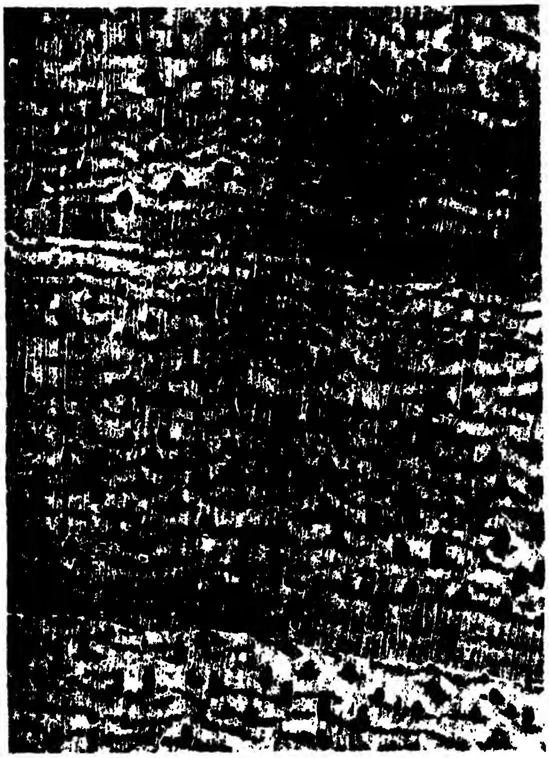
This tree yields one of the most important timbers in peninsular India. The sapwood is pale yellowish white or white, narrow; heartwood, golden yellowish brown with darker streaks, staining yellow when damp and turning darker on exposure, broadly interlocked-grained, medium coarse-textured, strong, tough, very hard and moderately heavy (sp. gr., 0.796; wt., 801 kg./cu.m.). The wood is medium refractory and air-seasons well without splitting, warping or developing surface cracks to any appreciable extent. The heartwood, which is often unsound, should be boxed during conversion to prevent split-

ting. The logs should be converted green and stored under cover. The best results, however, are obtained by converting green logs into planks and scantlings, immersing them in running water for 6 weeks or in stagnant water for 4 months, followed by seasoning under cover for a year. This results in removing the stain and producing a timber similar to that of *Dalbergia sissoo* in appearance. It takes 16–20 days for kiln-seasoning and needs slow and careful drying. The timber is fairly durable in exposed positions and very durable under cover; graveyard tests have shown a durability of 22 years and over at Dehra Dun though some tests elsewhere are said to indicate a shorter life period (Pearson & Brown, I, 392–95; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1,** 96; Trotter, 1944, 13, 155; Rehman, *Indian For.*, 1956, **82,** 252; Purushotham *et al.*, ibid., 1953, **79,** 49; Prasad *et al.*, ibid., 1964, **90,** 32).

The wood is easy to saw but rather difficult to work to a good finish. It machines well and takes a good surface, but requires a considerable amount of filing and takes a lasting polish. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 115; strength as a beam, 105; stiffness as a beam, 95; suitability as a post, 95; shock-resisting ability, 135; retention of shape, 75; shear, 115; and hardness, 135 (Pearson & Brown, I, 395; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 58, Sheet No. 17).

The timber is chiefly used for building purposes, as doors, window frames, rafters, beams and posts and as a substitute for teak after suitable seasoning and treatment. It is used in the construction of railway carriages, wagons, carts and boats, and occasionally for ship building; it is also used for railway sleepers, electric transmission poles and pit-props in mines. It is employed for a variety of other purposes such as agricultural implements, drums, tool handles, camp furniture, mathematical instruments, picture frames, combs, cheap guns, sport rifles and parts of textile-looms. It is found suitable for chipboards, and carving, joinery and cabinet-work. It can also be used in the building of timber bridges [Pearson & Brown, I, 395; Trotter, 1944, 155, 211, 215–16, 220, 222, 226; *For. Abstr.*, 1950, **11,** 536; *J. Timb. Dryers' & Pres. Ass. India*, 1956, **2**(1), 22; Narayanamurti & Jain, *Res. & Ind.*, 1963, **8,** 4; IS: 399–1952; Masani & Bajaj, *Indian For.*, 1962, **88,** 750].

Mixed with other woods it can be utilized in the manufacture of pulp for wrapping paper. It is used as a fuel; calorific value: sapwood—4,904 cal., 8,826



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 110—PTEROCARPUS MARSUPIUM—TRANSVERSE SECTION OF WOOD (×10)

B.t.u.; heartwood–5,141 cal., 9,255 B.t.u. (Guha, *Indian For.*, 1961, **87,** 194; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 21).

The bark contains *l*-epicatechin and a reddish brown colouring matter. The bark is occasionally employed for dyeing. The heartwood yields liquiritigenin, *iso*liquiritigenin, a neutral unidentified component (m.p. 160°), alkaloid (0.017%) and resin (0.9%). The wood also contains a yellow colouring matter (0.25%) and an essential oil and a semi-drying fixed oil (0.52%) (Sawhney & Seshadri, *J. sci. industr. Res.*, 1956, **15C,** 154; Bose *et al.*, *J. Indian chem. Soc., industr. Edn*, 1955, **18,** 143; Bhargava, *Proc. Indian Acad. Sci.*, 1946, **24A,** 496, 501).

The tree yields a gum-kino which exudes when an incision is made through the bark up to the cambium. The exudate is collected and dried in the sun or shade and yield of dried gum is reported to be c. 340 g. per tree. The gum is said to be obtainable in large commercial quantities though reliable figures of supplies are not available. Extraction of the gum is not encouraged in some areas as it is believed to have

an unfavourable effect on the timber (Puntambekar & Batra, *Indian For. Leafl.*, No. 44, 1943, 5; Krishnamurti Naidu, 143; Information from the Chief Conservator of Forests, Mysore).

Kino is included in I.P.C. and was official in certain European pharmacopoeias up to 1947. It occurs in small (3–5 mm.), angular, glistening, brittle fragments, appearing almost black in colour, but the edges when viewed by transmitted light are seen to be ruby-red and transparent. It is odourless and bitter with astringent taste and colours saliva pink when masticated. Kino contains a non-glucosidal tannin kinotannic acid (25–80%), kinoin ($C_{28}H_{24}O_{12}$) and kino-red ($C_{28}H_{22}O_{11}$), in addition to small quantities of catechol (pyrocatechin), protocatechuic acid, resin, pectin and gallic acid. Kino-red is the anhydride of kinoin, which is a phlobaphene produced from kinotannic acid by the action of an oxidase enzyme present in the kino. The therapeutic value of kino is due to kinotannic acid, which forms 70–85 per cent of the drug of good quality. Kino is powerfully astringent and was formerly used widely in the treatment of diarrhoea and dysentery. It is locally applied in leucorrhoea and in passive haemorrhages. It is also used for toothache. Kino finds application in dyeing, tanning and printing and is of potential use for the paper industry (I.P.C., 133; Kirt. & Basu, I, 828; U.S.D., 1955, 1730; Hocking, 183; Wallis, 446; Wren, 196; Trease, 387; Puntambekar & Batra, loc. cit.).

The bark is used as an astringent and in toothache. The flowers are said to be used in fever. The bruised leaves are considered useful as an external application for boils, sores and skin diseases. The leaves make an excellent fodder and are valuable as manure in arecanut plantations. The analysis of the leaves is as follows: moisture, 78.8; mineral matter, 7.5; nitrogen, 2.5; potash, 2.5; and phosphoric acid, 0.4% (Sonde, *Arecan. Bull.*, 1955–56, **6**, 78).

An aqueous infusion of the wood is said to be of use in diabetes and water stored in vessels made of the wood is reputed to have antidiabetic qualities. Tests on mice and rabbits with alcohol and aqueous extracts of the heartwood are said to have shown hypoglycaemic action, probably by hindering the absorption of glucose in the intestine (Trotter, 1944, 156; Ojha *et al.*, *Indian J. Pharm.*, 1949, **11**, 188; Gupta, *Indian J. med. Res.*, 1963, **51**, 716; Shah, ibid., 1967, **55**, 167; Joglekar *et al.*, *Indian J. Physiol.*, 1959, **3**, 76).

P. santalinus Linn. f. RED SANDERS, RED SANDAL WOOD

D.E.P., VI(1), 359; C.P., 909; Fl. Br. Ind., II, 239.

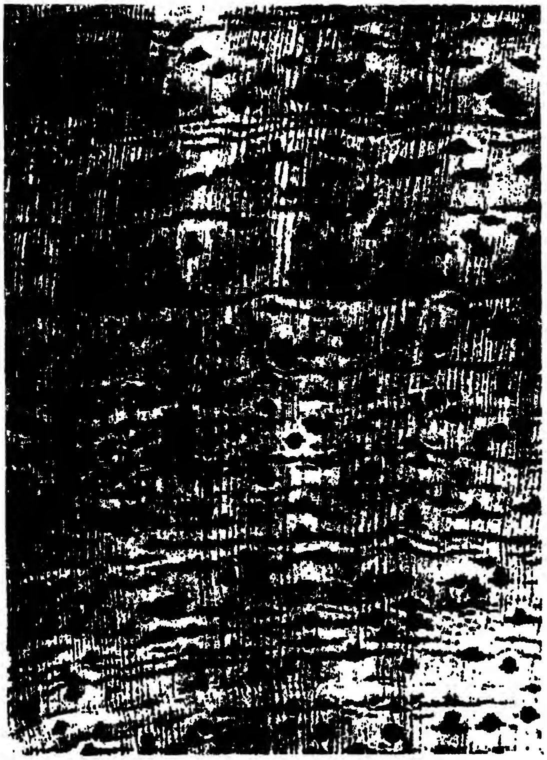
HINDI & BENG.—*Raktachandan, lalchandan*; MAR.—*Tambada chandana*; GUJ.—*Ratanjali*; TEL.—*Agarugandhamu, rakta gandhamu, yerra chandanamu*; TAM.—*Atti, sivappu chandanam*; KAN.—*Agaru, honne, kempugandha chekke*; MAL.—*Patrangam, tilaparnni*; ORIYA—*Raktachandan*.

TRADE—*Red Sanders*.

A small to medium-sized, deciduous tree, up to 10.0–11.0 m. in height and 1.5 m. in girth, restricted to parts of Andhra Pradesh, particularly Cuddapah district and neighbouring areas of Madras and Mysore States at altitudes of 150–900 m. Bark blackish brown, deeply cleft into rectangular plates, and exuding a deep red juice when cut; leaves usually imparipinnate: leaflets 3, rarely 5; flowers yellow, in simple or sparingly branched racemes; pods *c.* 5 cm. in diam. including the wing, the central hard and long portion containing the seed; seeds reddish brown, smooth, leathery.

Red Sanders has a very restricted natural range and grows typically on dry, hilly, often rocky ground and is occasionally found growing on precipitous hillsides. It requires perfect drainage, and is found mainly on gravelly soil on formation of gneiss, quartzite, shale or laterite, growing particularly well on lateritic soil; it has also been planted successfully on rich alluvial ground. It cannot withstand waterlogging. In its natural habitat, the tree experiences a comparatively hot, dry climate, with a normal rainfall of about 88–105 cm. received from both the North-east and South-west monsoons. It is a strong light demander and does not tolerate overhead shade and is fairly fire-hardy. In South India, the tree is planted as a wind-break around citrus orchards. It is also recommended for gardens and avenues [Troup, I, 273; Katyal, *Indian Fmg, N.S.*, 1956–57, **6**(1), 36].

Natural regeneration through seeds is profuse and the conditions required for successful regeneration are similar to those for *P. marsupium*. For artificial reproduction, one-year old seedlings are transplanted from the nursery into bamboo baskets and then planted in prepared pits during rains at a spacing of 3.5–4.5 m. The rate of growth is slow with mean annual girth increments of 1.3–2.0 cm. The tree grows to some extent from cuttings, provided these are irrigated regularly. It coppices very well and produces root suckers freely. For regeneration of forests, a simple coppice system with a rotation of 40 years is



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 111—PTEROCARPUS SANTALINUS—TRANSVERSE SECTION OF WOOD (×10)

being followed, but shelter-wood system has been recommended as more suitable (Troup, I, 275; Ramakrishna, *Indian For.*, 1962, **88,** 202).

The sapwood is white; heartwood, claret-purple with streaks, or purplish black or almost black, dull, interlocked-grained, medium fine-textured, very strong, extremely hard, very heavy (sp. gr., 1.109; wt., 1,105 kg./cu.m.): the wood is heavily impregnated with reddish-brown gum and contains a red dye, santalin, for which it has been valued in the past. The timber seasons well and is highly refractory. It is immune to white ants and other insects and does not require antiseptic treatment (Pearson & Brown, I, 396, 398; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1,** 96).

The timber is difficult to saw in the dry state. It works, however, well with hand tools. It takes a high and lasting polish, but requires care to bring to a smooth surface. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 165; strength as a beam, 135; stiffness as a beam, 110; suitability as a post, 135; shock-resisting ability, 140; retention of shape, 100; shear, 200; and hardness, 270 (Pearson & Brown, I, 398; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1,** 58, Sheet No. 17).

The timber is highly prized for house posts. It is also used for agricultural implements, for poles, shafts and bent rims of carts and for picture frames, boxes and other joinery purposes. Small pieces are carved into dolls and images. It is exported to Japan where it is used in the manufacture of a musical instrument called Shamisen; for this purpose, timber with a wavy or rippled grain fetches fancy price as it produces resonance par excellence, but the wavy grain is a freak, and it is not possible to identify such trees externally. The wood yields excellent charcoal, and fuel of the best quality is obtained from diseased and crooked trees (Pearson & Brown, I, 398–99; Gamble, 260; Ramakrishna, loc. cit.; Whitehead, *Indian For. Bull., N.S.*, No. 34, 1917, 1).

Red Sanders wood contains 16 per cent of a red colouring matter santalin [santalic acid, $C_{30}H_{16}O_6(OCH_3)_4$] possessing a quinonoid structure. Santalin yields a blood red solution with alcohol, yellow with ether and violet with ammonia and caustic alkalies, but is insoluble in water. The wood also contains desoxysantalin ($C_{20}H_{16}O_6$) supposed to be a naphthaquinonoid derivative, the yellow isoflavone santal, and two unidentified pigments A and B, besides three colourless substances, viz. pterostilbene, pterocarpin (0.25%) and homopterocarpin (0.2%). Pterostilbene is toxic to the brown fungus *Coniophora cerebella*. The ground wood was chiefly used for dyeing wool, cotton and leather and for staining other woods. Roots and stumps were also used for the purpose. The dye is also used for colouring pharmaceutical preparations and foodstuffs and is suitable for colouring paper pulp. A histological stain has been prepared from the alcohol-soluble fraction of the heartwood. The bark is sometimes used in the curing of arecanuts (I.P.C., 210; Wehmer, I, 552; Lal, *Proc. nat. Acad. Sci. India*, 1939, **9,** 83; Wise & Jahn, I, 633; Sawhney & Seshadri, *J. sci. industr. Res.*, 1954, **13B,** 6; Mayer & Cook, 147; Hoppe, 749; King, *Chem. & Ind.*, 1953, 1325; Cameron, 95; U.S.D., 1955, 1182; *Perfum. essent. Oil Rec.*, 1962, **53,** 628; Puntambekar & Batra, *Indian For. Leafl.*, No. 44, 1943, 7; Sen Gupta & Chakravarti, *Bull. Calcutta Sch. trop. Med.*, 1961, **9,** 52).

Red Sanders wood is considered astringent, tonic, and diaphoretic. A paste of the wood is used as a cooling external application for inflammations and

TABLE 1—EXPORT OF RED SANDERS WOOD POWDER
(Qty in kg. and Val. in Rs.)

Year	Qty	Val.
1962-63	18,382	8,255
1963-64	20,566	15,271
1964-65	107,307	57,117
1965-66	5,926	11,492
1966-67	2,025	2,657

headache. It is said to be useful in bilious affections and skin diseases. A decoction of the fruit is used as an astringent tonic in chronic dysentery (I.P.C., 210; Kirt. & Basu, I, 826).

Leaves are used as cattle fodder (Cameron, 96).

Large quantities of Red Sanders wood are said to have been exported regularly from this country to Europe where it was employed for extraction of dye but the demand for the wood declined towards the end of the 19th century with the increasing use of artificial dyes. Small quantities of Red Sanders wood powder are, however, exported and the chief importing countries are Japan, Hongkong, Germany and Ceylon (Table 1). Some quantities of the wood (111 cu.m. valued at Rs. 317,163 in 1965–66 and 107 cu.m. valued at Rs. 276,769 in 1966–67) were exported mainly to Japan.

*PTEROCOCCUS Hassk. (*Euphorbiaceae*)

Fl. Br. Ind., V, 464; Fl. Assam, IV, 223.

A very small genus of twining, woody shrubs or undershrubs, with one species distributed in Asia and two others in Africa.

P. corniculatus Pax & Hoffm. syn. *Plukenetia corniculata* Sm. is a slender climber with ovate-oblong leaves, 5–10 cm. long and 2–5 cm. broad, reported from Sikkim Himalayas and upper Assam, extending up to Tenasserim and Malacca. It bears flowers in slender racemes, and has 4-winged capsules. Leaves have a sweet taste and smell of elder (*Sambucus* sp.), and are said to be used as vegetable in Sumatra and Malaya: they contain 5.6 per cent protein (on fresh wt.) (Burkill, II, 1833; Terra, *Bull. R. trop. Inst., Amst.*, No. 283, 1964).

PTEROCYMBIUM R. Br. (*Sterculiaceae*)

A small genus of trees distributed from Burma and Andaman Islands to the Philippines and New Guinea. One species occurs in India.

* This genus is included by some botanists in *Plukenetia* Linn. distributed in tropical America.

P. tinctorium Merrill syn. *Sterculia campanulata* Wall. ex Mast.

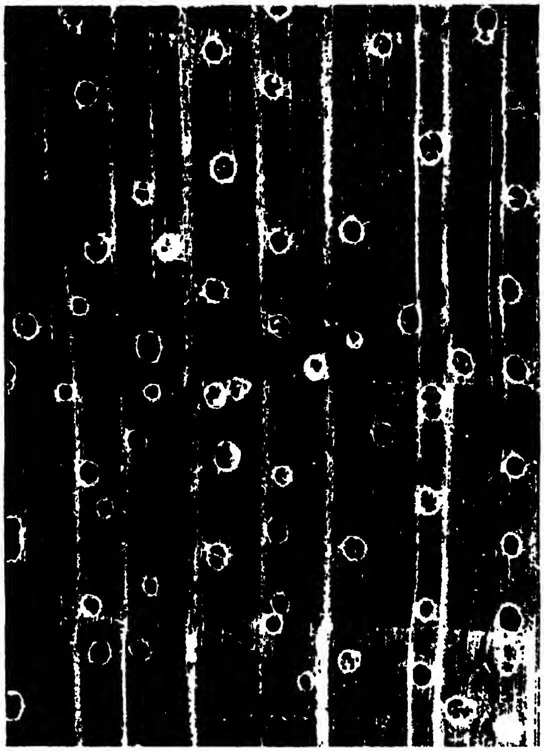
D.E.P., VI(3), 361; Fl. Br. Ind., I, 362; Brown, I, Pl. XXVII.

TRADE—*Papita*.

A large tree, up to 40 m. in height and 3 m. in girth, with a straight cylindrical bole, up to 30 m. in length, found in Andaman and Nicobar Islands; it has also been successfully introduced in the west coast. Bark greyish, patchy; leaves 10–15 cm. × 7.5–12.5 cm., broadly ovate-cordate; flowers in panicles, bell-shaped, yellowish green; follicles membranous, boat-shaped; seeds globose. The tree is common in deciduous forests, often occurring gregariously; it is grown also in plantations in Andaman Islands.

Natural regeneration of *papita* is usually regarded as adequate. It is artificially propagated by seeds, which when sown in irrigated beds during dry season germinate in seven days; germination percentage is 90 but survival percentage is 40–50. Viability of seeds is low and only fresh seeds, not more than two months old, germinate well. Seeds preserved in charcoal, however, seem to remain viable for about 6 months. Seedlings have a fast rate of growth and attain a height of 1.8–2.7 m. in one year and 4.5–6.0 m. in two years. Transplanting is best done with basket seedlings when they are only a few months old and not more than 75 cm. in height; survival percentage is as much as 45. The tree is a light demander. In the Andamans, it is usually grown in mixed plantations (*Indian For.*, 1952, **78**, 274; Ganapathy & Rangarajan, ibid., 1964, **90**, 758).

The tree yields a useful, light, soft timber, which is in considerable demand. Wood, uniformly creamy-white in colour; sapwood and heartwood not distinct; straight-grained, even- and coarse-textured, very soft and light (sp. gr., *c.* 0.33; av. wt., 336 kg./cu.m.). It is easy to season, but requires quick drying. Logs should be converted absolutely green immediately after felling during dry weather, and sawn material open-stacked vertically, allowing free circulation of air. Kiln-seasoning, however, gives the best results; 2.5 cm. thick planks take 4–5 days to season and require an initial steaming for about 2 hours at 55° and 100 per cent R.H. for sterilization. *Papita* wood is very perishable and liable to fungal staining and insect attack. If properly seasoned and treated with preservatives, it can, however, last well under cover. It is very easy to saw and work both by hand and by machine; when planed on the quarter, it works up to a brilliant shiny surface. The data for the com-



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 112—PTEROCYMBIUM TINCTORIUM—TRANSVERSE SECTION OF WOOD (×10)

parative suitability of *papita* timber, expressed as percentages of the same properties of teak, are: weight, 45; strength as a beam, 45; stiffness as a beam, 50; suitability as a post, 45; shock-resisting ability, 40; retention of shape, 80; shear, 65; and hardness, 25 (Pearson & Brown, I, 152–53; Trotter, 1944, 163; Indian Woods, I, 213; Rehman, *Indian For. Bull., N.S.*, No. 170, 1953, 4; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 60, Sheet No. 19).

The wood is used mainly for match-boxes and splints, light packing cases and rafts. It is suitable for planking, laminated and insulation boards and for toys. In the Philippines, it is reported to be used also for fish net floats, wooden shoes and hats. *Papita* wood has been found to be suitable for the manufacture of newsprint and writing and printing papers. Analysis of the wood gave the following values (oven-dry basis): cellulose (Cross & Bevan), 59.50; pentosans, 15.51; lignin, 23.83; and ash, 1.01%. On employing suitable grinding conditions, the wood yielded mechanical pulp suitable for newsprint. Digestion of the wood by the sulphate process (caustic soda and sodium sulphide in the ratio of 2:1; total chemicals, 22 or 24% on oven-dry raw material) for 5 hours at 153° gave pulps (yield of bleached pulp, 48%; av. fibre length, 1.49 mm.) suitable for the production of writing and printing papers. Admixture of bamboo bleached pulp (32%) is reported to improve the strength properties of the papers. Bark is used for making ropes in the Philippines. It contains 10 per cent tannin. Bark and fruits are reported to be poisonous. The tree yields a gum resembling gum tragacanth (Trotter, 1944, 163–64; Indian Woods, I, 213; Desch, 1954, 577; Burkill, II, 1834; Bhat & Virmani, *Indian For.*, 1953, **79**, 169; 1952, **78**, 222; Brown, 1941, II, 442; Baens *et al.*, *Philipp. J. Sci.*, 1934, **55**, 177).

PTEROPSIS Desv. (*Polypodiaceae*)

Copeland, 194; Nayar, *Bull. nat. bot. Gdns, Lucknow*, No. 106, 1964, Fig. 29–30.

A small genus of epiphytic ferns distributed from Malagasy to the Solomons. While dealing with *Drymoglossum* for the Wealth of India, Vol. III, 114, the genus was referred to *Pteropsis* Desv. following Copeland. Since then, the genus *Drymoglossum* Presl has been conserved against *Pteropsis* Desv., as the latter genus has been shown to include five different genera according to modern views. The Indian species *Drymoglossum carnosum* (Wall.) Sm. is considered a synonym of *Lemmaphyllum carnosum* (Sm.) Presl.

Lemmaphyllum carnosum is an epiphytic fern found in Nepal, Sikkim and Bhutan, at altitudes of 600–1,500 m. It is reported to be medicinally useful. The fronds possess pectoral, diuretic and astringent properties. In China, they are used in urinary calculus and rheumatism. They are applied as poultices on swellings of legs and also to cure infection of nails (whitlow) and animal bites. A decoction of fronds is administered internally to stop haemorrhages (Caius, *J. Bombay nat. Hist. Soc.*, 1935–36, **38**, 354; Crevost & Petelot, *Bull. econ. Indoch.*, 1935, **38**, 115).

PTEROSPERMUM Schreb. (*Sterculiaceae*)

A small genus of trees and shrubs distributed in tropical Asia. About 12 species occur in India, all of them yielding timber more or less very similar in weight and hardness, and hardly distinguished from one another for economic purposes. Many of these species are planted for ornament.

P. acerifolium Willd.

D.E.P., VI(1), 362; Fl. Br. Ind., I, 368 in part; Kirt. & Basu, Pl. 150.

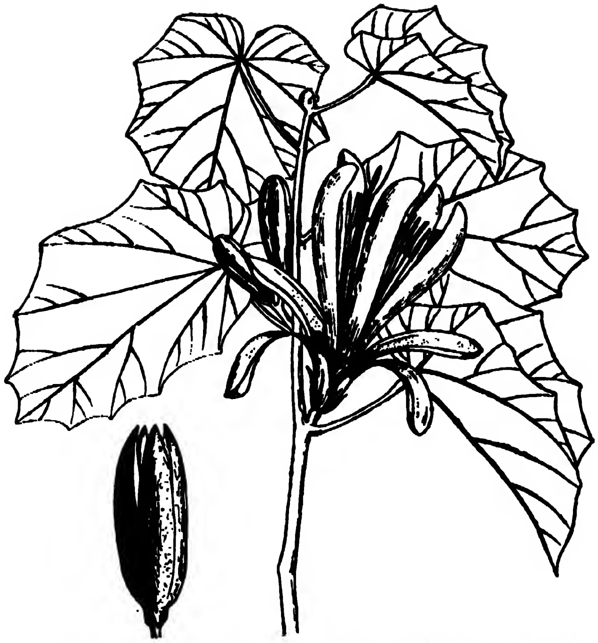


FIG. 113—PTEROSPERMUM ACERIFOLIUM—FLOWERING BRANCH AND FRUIT

HINDI—*Kanak-champa, kaniar, katha-champa, muchkund;* BENG.—*Kanak-champa, muskunda;* TEL. *Matsa kanda;* ORIYA *Kanako champa.*

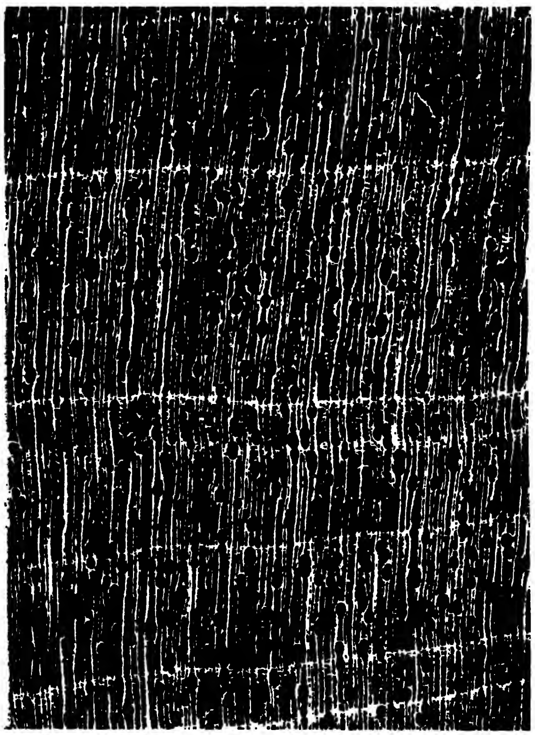
JAUNSAR *Mayeng;* ASSAM—*Hatipeala, morra, moragos;* KHASI—*Dieng-khong-swet, dieng-tharomasi;* LUSHAI—*Waisip-thing;* NEPAL—*Hattipaila;* LEPCHA *Numbong.*

TRADE *Hathipaila.*

An evergreen tree, up to 24.0 m. in height and c. 2.5 m. in girth, with a clean bole up to 12 m., found in the sub-Himalayan tract and outer valleys from Yamuna eastwards to West Bengal, and in Assam and Manipur, up to an altitude of c. 1,200 m., extending southwards into Ramnagar hills of Bihar and in western ghats of Konkan and North Kanara; it is also common in the Andamans. Bark greyish brown: leaves variable in size and shape, 25–35 cm. × 15–30 cm., entire or variously lobed, oblong, cordate or sometimes peltate: flowers large, 12-15 cm. in diam., axillary, solitary or in pairs, white, fragrant; capsules oblong, 5-angled, dark brown, woody; seeds winged, brown.

The tree is found in a variety of situations, such as swamp forests of Dehra Dun, evergreen rain forests of North Kanara and along the river banks in the sub-Himalayan tract. It is also commonly planted in gardens and avenues. It is a moderate shade-bearer and fairly frost hardy. The tree coppices well and produces root suckers in abundance. Natural regeneration is by both seeds and root suckers. Artificial propagation can be done through transplanting the nursery-raised seedlings, when they are about 7.5 cm. in height: direct sowings, properly weeded and watered, produce better results. Stump planting has also proved successful. The rate of growth is rapid; weeded and irrigated sowings in Dehra Dun showed a height growth of about 1.8 m. per annum (Troup, I, 160–62; Kadambi & Dabral, *Indian For.*, 1955, **81,** 129).

The sapwood is pale white; heartwood light pinkish red, turning a little darker on exposure, rather lustrous, even- and somewhat interlocked-grained, fine-textured with fine inconspicuous ripple marks, soft to moderately hard and light to moderately heavy (sp. gr., 0.598: wt., 593–761 kg./cu.m.). The timber is not durable in the open, but fairly so under cover; graveyard tests show an average life of about two years. It is very liable to insect attack, but is only partially treatable. The timber seasons well with care and has only a slight tendency to develop surface



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 114—PTEROSPERMUM ACERIFOLIUM—TRANSVERSE SECTION OF WOOD (×10)

cracks. Green conversion, followed by stacking under cover and protection from the direct sun gives satisfactory results. The timber is usually sawn green and presents no difficulties. It is easy to work, both by hand and on the machine, and to turn and peel. It finishes to an excellent surface, taking a fine polish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 90; strength as a beam, 85; stiffness as a beam, 85; suitability as a post, 85; shock-resisting ability, 125; retention of shape, 80; shear, 105; and hardness, 100 [Pearson & Brown, I, 160–61; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1**, 96; Purushotham *et al., Indian For.*, 1953, **79**, 49; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 82; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 58, Sheet No. 17].

The supply of this timber is mainly from Assam. The timber is used for planks, packing cases and turnery articles. It is suitable for veneers, plywood for general use, constructional work, panelling, bridges, boats, tool handles, box shooks and matches and match-boxes. It is a pretty and moderately good bending wood and is used for furniture, toys, walking sticks and other ornamental articles. It has also been recommended for mathematical instruments and brush backs (Pearson & Brown, I, 161; Trotter, 1944, 219, 229; Limaye, loc. cit.; Uphof, 300; Rodger, 47; IS: 399–1952; Rehman *et al., Indian For.*, 1956, **82**, 469).

The flowers are sharply bitter and acrid in taste, and render water mucilaginous. They are said to be rich in carbohydrates, and may be eaten. They are used as a general tonic and occasionally as a cure for blood troubles, inflammation, ulcers, tumours and leprosy, and also employed as an insect repellent and disinfectant. In Konkan, the flowers and bark are charred and mixed with *kamala* powder from *Mallotus philippensis* for application to small-pox eruptions. The flowers are smoked along with tobacco. The leaves are used as platters and for thatching huts and packing tobacco (Kirt. & Basu, I, 375; Burkill, II, 1835; Bressers, 13; Benthall, 58).

The seeds yield 22.6 per cent of a pale yellow oil with the following characteristics: $n_D^{40°}$, 1.4660; sap. val., 191.6; acid val., 12.2; and iod. val., 87.8. The oil gives Halphen reaction [Krishna *et al., Indian For. Rec., N.S., Chem.*, 1936, **1**(1), 29].

P. canescens Roxb. syn. *P. suberifolium* Lam. non Roxb.

D.E.P., VI(1), 362; Fl. Br. Ind., I, 367; Kirt. & Basu, Pl. 149.

HINDI, BENG. & MAR.—*Muchkand;* TEL.—*Tada, naradu, lolagu, pothadi;* TAM.—*Sempulavu, thadei;* ORIYA—*Baelo, giringa.*

A small to medium-sized tree, found in the forests of northern Circars, Mysore and Madras, ascending to an altitude of *c.* 900 m.; it is occasionally planted in West Bengal. Bark greyish, smooth; leaves oblong or obovate-oblong, coriaceous; flowers 1–3 on each axillary peduncle, white or yellowish white, fragrant; capsules ovoid-oblong, sub-angular, tapering at both ends, woody, white-velvety: seeds 2–4, winged.

The tree has a fast rate of growth with an annual girth increment of about 5.8 cm. The wood structure is grossly the same as that of *P. acerifolium.* It is light red, very tough, moderately hard and heavy (wt., 577–641 kg./cu.m.). It is used for carts, gun-stocks and packing cases and as fuel (Gamble, 101; Lewis, 65).

The flowers are bitter in taste and render water mucilaginous. They are made into a paste with rice and vinegar for application in hemicrania. A paste prepared from the leaves is also used in headache.

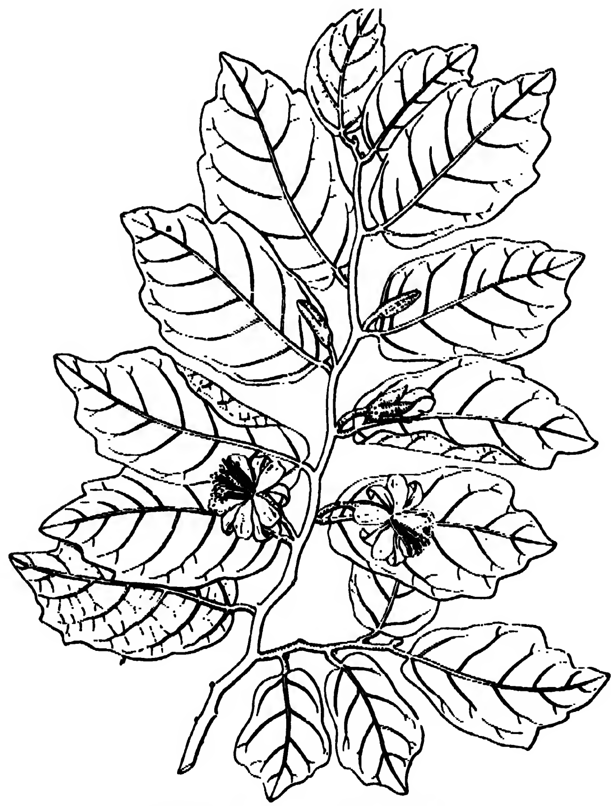


FIG. 115—PTEROSPERMUM CANESCENS—FLOWERING BRANCH

The bark and flowers, like those of *P. acerifolium*, are charred and mixed with *kamala* powder for use on small-pox eruptions. The bark is used to clarify the syrup in jaggery making. The fruits are made into a jam (Kirt. & Basu, I, 374; Rama Rao, 49; *Annu. Rep. Indian cent. Sugarcane Comm.*, No. 16, 1961, 66; Krishnamurthi, 135).

P. diversifolium Blume syn. *P. glabrescens* Wight & Arn.

Fl. Br. Ind., I, 367, 369; Corner, I, Fig. 227, 228.

TAM.—*Mooli, vatta pulavu*; MAL.—*Pambarom*.

A medium-sized, fast growing tree, up to 21.0 m. in height and 1.5 m. in girth, met with in the forests of the western ghats at low elevations; also planted in gardens. Leaves broadly elliptic to obovate, up to 24 cm. long, coriaceous; flowers solitary or in pairs, axillary, white, fragrant; capsules woody, 5-angled.

The sapwood is dirty white and heartwood is not sharply demarcated from it; heartwood light drab or purplish, slightly cross-grained, moderately fine-textured, moderately strong and hard, tough and heavy (sp. gr., 0.665; wt., 465–702 kg./cu.m.). It seasons well with little degrading, works easily and takes fine finish. The timber does not seem to be much utilized in India. In the Philippines, it is considered durable for interior work and is used for building construction, furniture, tool handles, vehicle shafts, household and agricultural implements, turnery, and combs. It is also used for parts of bullock carts, and for rice pounders. In Java, it is said that the timber is excellent in contact with water and is used for bridges, boats and oars and parts of houses in contact with the soil; in the Philippines, however, the wood is not credited with such durability. The wood yields a pale yellow-brown pulp, which can be easily bleached and converted into a paper of silky appearance; preparation of the pulp, however, needs drastic treatment (Desch, 1954, 578–79; Gamble, 102; Burkill, II, 1835).

The bark is chewed with betel leaves as a masticatory. In the Philippines, the bark is cut up and boiled and used for dyeing fishing nets and cloth. The bark of the root is said to act as a fish-poison (Burkill, II, 1835–36).

P. lanceaefolium Roxb. (BENG.—*Ban kalla*; ASSAM—*Bon-nahor, bon baguri*; KHASI—*Dieng-nor-sha, dieng-pen-swang*; NEPAL—*Singani*; LUSHAI—*Sakhi-pelhnam*) is a small to medium-sized tree with lanceolate or oblong leaves, and large, white, fragrant flowers, found in the sub-Himalayan tracts and in Assam and Manipur, ascending to an altitude of *c.* 1,200 m. It is often planted in the plains of Punjab and West Bengal, and is propagated through cuttings. The leaves are chewed to redden the lips. The wood is moderately hard but is not much used (Firminger, 603; Fl. Assam, I, 159).

P. reticulatum Wight & Arn. (TAM.—*Mulipulavu, tholpuli*; MAL.—*Mala viriam*) is a tree, up to 24 m. in height and *c.* 2 m. in girth, found at low elevations in the evergreen forests of the western ghats from Kanara southwards; it is also grown in gardens and planted along the roads. The wood is reddish brown with darker streaks, moderately hard, rather rough and heavy (wt., 689 kg./cu.m.). It is used for boats and house building, and is also said to be suitable for match-boxes and splints (Bourdillon, 49; Rama Rao, 49).

P. rubiginosum Heyne ex Wight & Arn. (TAM.—*Chittilai pulavu*; MAL.—*Malam thodali*) is a graceful tree, up to 24 m. in height and 2 m. in girth, found in the evergreen forests of western ghats from Kanara southwards and in the Anaimalai hills up to an altitude of 900 m. The sapwood is white; heartwood pink to red, close-grained, moderately hard, heavy (wt., 545–801 kg./cu.m.) and easy to saw. The wood is pretty, but cannot be obtained in broad pieces. It is used locally for house building and boats. It is also considered suitable for match-boxes, splints and paper pulp (Bourdillon, 49; Gamble, 101; Indian Woods, I, 208; Rama Rao, 49).

P. semisagittatum Buch.-Ham. ex Roxb. (LUSHAI—*Mukau*) is a tree, up to 18 m. in height and 2 m. in girth, with usually fluted stem, and greyish bark found in the Lushai hills, up to an altitude of *c.* 900 m. It is occasionally cultivated in Bihar, West Bengal, Orissa and parts of Madras. The rate of growth is moderately fast with an annual girth increment of about 2.5 cm. The wood is reddish grey, fairly hard, durable and heavy (wt., 641–801 kg./cu.m.). It is used for axe handles and is a good fuel. The bark is used as a masticatory (Gamble, 101–02; Rodger, 30; Burkill, II, 1834).

P. xylocarpum Santapau & Wagh syn. *P. heyneanum* Wall. ex Wight & Arn. (TEL.—*Lolgu, tada*; TAM.—*Pulavu*; KAN.—*Kesali, copin*; MAL.—*Palaka unam, thopali*; ORIYA—*Giringa*) is a handsome tree with large white fragrant flowers and toothed or lobed leaves (10.0–15.0 cm. × 5.0–7.5 cm.) distributed in parts of the Deccan Peninsula. The leaves are used in leucorrhoea. They are also smoked like tobacco. The wood is light red, hard and heavy (wt., 689 kg./

cu.m.), resembling that of *P. acerifolium* in structure (Kirt. & Basu, I, 375–76; Gamble, 102).

PTERYGOTA Schott & Endl. (*Sterculiaceae*)

A genus of trees distributed in the tropics, chiefly of the Old World. One species occurs in India.

P. alata R. Br. syn. *Sterculia alata* Roxb.

D.E.P., VI(3), 360; Fl. Br. Ind., I, 360; Talbot, I, Fig. 87.

BENG.—*Buddha narikel, tula;* TAM.—*Kodaittondi;* KAN.—*Kolugida, tattele mara;* MAL.—*Kodathani, anathondi, pathondi.*

NEPAL—*Labshi;* ASSAM—*Tula, pahari;* KHASI—*Dieng-soh-lakor;* LUSHAI—*Phunber-pui;* ANDAMANS—*Letkok.*

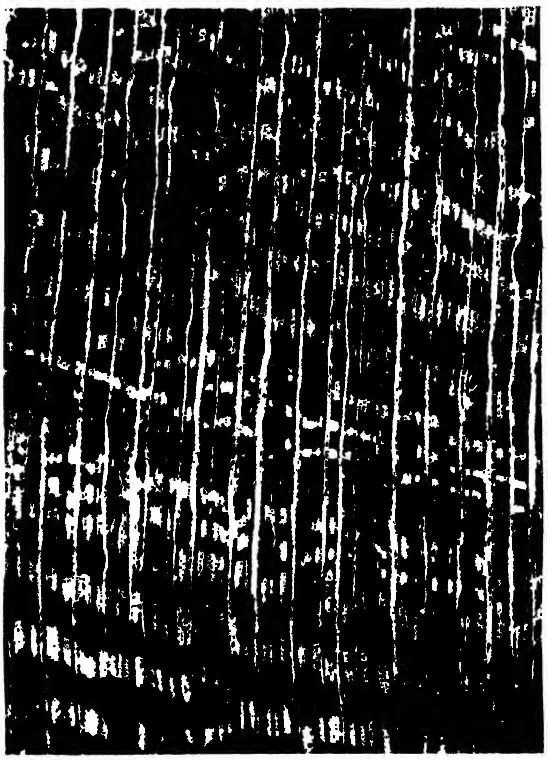
TRADE—*Narikel.*

A tall, handsome, often buttressed tree, up to 45 m. in height and 3 m. in girth, with a straight, cylindrical bole up to 30 m., found in the eastern Himalayas and Assam and in the western ghats from North Kanara southwards; it is also found in the Andamans. The tree is commonly cultivated for ornament in avenues and gardens. Bark greyish brown, fairly smooth; leaves 10–25 cm. × 7–20 cm., ovate-cordate; flowers brownish yellow, in panicles; follicles sub-globose, woody; seeds many, oblong, compressed, *c.* 5 cm. long, with a terminal corky wing.

The tree is found sporadically, chiefly in the moist situations in evergreen forests, often towering over the surrounding vegetation; it also does well in dry localities. Natural regeneration through seed is quite common, the seedlings being capable of withstanding fairly dense shade. Artificial reproduction may be done through direct sowing of freshly collected seeds or transplanting *c.* 20 cm. high nursery-raised seedlings during the rainy season, giving a spacing of *c.* 2 m. × 2 m. Stump-planting has also been found to be successful. The rate of growth of the tree is fast, with 2–5 rings per 2.5 cm. of radius; it coppices well (Troup, I, 152; Haines, II, 77; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 102: *For. Res. India*, 1952–53, pt II, 3; *Indian For.*, 1948, **74**, 279).

The wood is white, when first exposed, turning greyish with age. It is generally straight-grained, coarse-textured, moderately hard and light (sp. gr., 0.25–0.62; wt., 385–657 kg./cu.m.). It is easy to season but should be converted soon after felling and open-stacked under cover to prevent discolouration. Kiln-seasoning, however, gives the best results. Planks 2.5 cm. in thickness take 4–5 days to season and require an initial steaming for two hours at 55° and 100 per cent R.H. for sterilization. If properly seasoned, the wood is fairly durable under cover, but is easily perishable in exposed positions, as it is susceptible to various types of insect attacks and fungal rots. It is easy to saw and peel, finishing to a good surface; cut on the quarter it presents a somewhat lustrous surface with a marked silver grain. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 85; strength as a beam, 85; stiffness as a beam, 85; suitability as a post, 85; shock-resisting ability, 100; retention of shape, 70; shear, 90; and hardness, 75 (Pearson & Brown, I, 150; Indian Woods, I, 217–18; Bourdillon, 46; Rodger, 22; Rehman, *Indian For. Bull., N.S.*, No. 198, 1956, 1; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 60, Sheet No. 19).

The wood is chiefly used for tea boxes and other light packing cases. It is also suitable for planking and plywood and for making light furniture, match-boxes and splints. In Nepal, the wood is employed for making drums. It is a very good fuel



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 116—PTERYGOTA ALATA—TRANSVERSE SECTION OF WOOD (×10)

I.C.A.R., New Delhi

PTERYGOTA ALATA—AN AVENUE

wood—calorific value, 5,160 cal., 9,290 B.t.u. Analysis of the wood gave the following values (oven-dry basis): cellulose (Cross & Bevan), 56.2; lignin, 21.1; pentosans, 16.8; and ash, 1.3%. Experiments on chemical pulping (av. fibre length 1.19 mm., and diam. 0.03 mm.) of the wood showed that it was not economical for the production of writing and printing papers. Bark yields a fibre used for rough cordage (Pearson & Brown, I, 152; Indian Woods, I, 218; Limaye, loc. cit.; Trotter, 1944, 219; Fl. Assam, I, 154; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 24; Bhat & Gupta, *Indian For. Bull., N.S.*, No. 180, 1954, 1).

The roasted seeds are eaten in parts of Assam and Burma. They are reported to be used as a cheap substitute for opium, although narcotic properties have never been attributed to this tree. Dried seeds yield (35%) a fixed oil, having the following characteristics: sp. gr.$^{30°}$, 0.905; sap. val., 101; acet. val., 81.7; iod. val., 95.09; R.M. val., 0.41; Polenske val., 0.42; and unsapon. matter (mostly phytosterols), 0.86%. The fatty acid composition of the oil is as follows: stearic, 7.5; palmitic, 14.5; linoleic, 32.4; and oleic acid, 44.0% (Fl. Assam, I, 154; Benthall, 51; Pillai, *Rep. Dep. Res., Univ. Travancore*, 1939–46, 188).

Ptychotis — *see* **Trachyspermum**

Pudding Grass — *see* **Mentha**

PUERARIA DC. (*Leguminosae; Papilionaceae*)

A small genus of twining herbs or shrubs with tuberous roots, distributed in South-East Asia and Pacific Islands, with many species recorded in India. Two species, *P. lobata* and *P. phaseoloides*, are widely cultivated as cover, green manure or fodder crop.

***P. lobata** (Willd.) Ohwi syn. *P. thunbergiana* (Sieb. & Zucc.) Benth.: *P. hirsuta* Schneid. non Kurz

KUDZU

Bailey, 1947, III, 2856.

A perennial, hairy vine with long, thickened or tuberous roots, native of China and Japan, now introduced and grown in many tropical and subtropical countries, including India. Leaves trifoliolate: leaflets entire or shallowly 2–3 lobed, pubescent; flowers mauve or violet coloured, fragrant, in dense pubescent racemes, 20–50 cm. long; pods flat, oblong linear, 5–10 cm. long, hairy, with 8–20 seeds.

* Some taxonomists consider *P. triloba* (Lour.) Makino as the correct name for this plant (Fl. Java, I, 632).

A hardy, vigorous growing vine, cultivated in its native area, Japan and China, for its edible roots. Kudzu was first introduced into U.S.A. as a trellis plant, but in later years proved to be a valuable crop for erosion control and forage. It was introduced into India about 1926 and experimentally grown for cover, green manure and fodder in Pusa (Bihar). While it yielded favourable results in Bihar, its performance at other regions, viz. Mysore, Coorg, South Kanara and Poona was poor; in Delhi and Almora (Uttar Pradesh), it was moderately successful. Poor results have also been reported with this plant in areas with a tropical climate, like Malaya and Equatorial Africa [O'Brien & Skelton, *Bull. Miss. agric. Exp. Sta.*, No. 438, 1946; Ahlgren, 132; Joshi, *Agric. Live-Stk India*, 1933, **3**, 586; Yegna Narayan Aiyer, 1950, 123; Nagasundara, *Indian Fmg, N.S.*, 1959–60, **9**(2), 33; Savur, *Madras agric. J.*, 1948, **35**, 241; Dabadghao, *Curr. Sci.*, 1949, **18**, 379; Khan & Misra, *Agric. Anim. Husb., Uttar Pradesh*, 1955, **6**(6), 11; Use of Leguminous Plants, 238].

As a cover crop and green manure plant, kudzu is evidently better adapted to moderately humid subtropical and warm-temperate regions than to pure tropical areas, for which *P. phaseoloides* is reportedly more suitable. Kudzu withers during winter in temperate areas but revives again with the approach of spring. It is also able to stand protracted drought because of its roots which penetrate deep into the soil. It can be propagated both by seeds and by rooted nodes (crowns) or rooted vine cuttings. In India and many other countries, it does not flower or set seed easily, and propagation by rooted cuttings is preferred. Planting is usually done in January–February, the planting distance depending upon how quick the cover is required. It requires regular cultivation in the first one or two years in order to enable it to produce numerous intertwining stolons which root at the nodes and serve to cover the area closely. Under Pusa (Bihar) soil conditions, it has been found to produce bacterial root nodules. It does not stand frequent and close cuttings and yields about 40 tonnes of green matter per hectare in three cuttings in Delhi [Gandhi, *Indian Fmg, N.S.*, 1954–55, **4**(10), 26; Joshi, loc. cit.; Whyte *et al.*, 320; O'Brien & Skelton, loc. cit.].

Kudzu is an ideal plant for a variety of situations where the soil is subject to erosion. It makes vigorous and rapid growth in places where most grasses and legumes do not come up. It yields large quantities of leaf litter which adds to the fertility of soil. It is

reported to suppress even weed growth (Gandhi, loc. cit.; Dalal & Patnaik, *Indian For.*, 1963, **89**, 468).

Kudzu is nutritive and palatable to all kinds of livestock and poultry. Its value as fodder is enhanced by the fact that it can be harvested in the months of April and May when green fodder is very scarce. It can be grown for pasture and hay also, the yield of hay ranging from 2 to 10 tonnes per hectare. It makes good silage and can be grown in admixture with Napier or other grasses. Analysis of the vine grown in Pusa and harvested in April, May, June and October gave the following ranges of values (air-dried material): moisture, 1.3-5.7; fat, 1.6-3.3; crude protein, 13.1-15.9; soluble carbohydrates, 39.2-47.7; crude fibre, 17.1-25.9; soluble mineral matter, 9.9-12.9; silica, 1.5-4.9; phosphorus, 0.20-0.23; and potassium, 1.6-3.4%. The mineral and vitamin values of the hay, according to a foreign source, are as follows: calcium, 161; phosphorus, 47; magnesium, 80; riboflavin, 0.8; and carotene, 4.4 mg./100 g. Kudzu is a good source of calcium and digestible protein. Feeding trials on goats carried out in Izatnagar indicated that kudzu vine hay (dig. protein, 10.3; total dig. nutrients, 28.7; and starch equivalent, 16.1 kg./100 kg.) compared well with cowpea hay, berseem hay and wheat bran in digestible protein value, but was inferior to legume hays in starch equivalent (Dalal & Patnaik, loc. cit.; Morrison, 327; Joshi, loc. cit.; Miller, 251, 424; Kehar & Deb Goswami, *Sci. & Cult.*, 1950-51, **16**, 77).

The roots of kudzu are tuberous and in favourable climatic conditions may grow to a great size and attain a weight of over 35 kg. They can be eaten boiled as vegetable. The edible portion of the fresh roots contains: moisture, 68.6; protein, 2.1; fat, 0.1; total carbohydrates, 27.1; fibre, 0.7; and ash, 1.4%; calcium, 15; phosphorus, 18; and iron, 0.6 mg./100 g. A glucoside daidzin, the aglucone daidzein, an *iso*flavone puerarin, 8-D-glucopyranosyl-4,7-dihydroxy *iso*flavone and its xyloside have been identified in the roots. The dried roots yield 40 per cent of a starch which resembles cassava starch and can be used in food and medicine (digestibility, 21.9%). In China and Japan, a kind of flour called Ko-fen is made from the roots; it is sweet and odourless and is used to make soup (Burkill, II, 1838; Porterfield, *Econ. Bot.*, 1951, **5**, 3; Wu Leung *et al.*, *Agric. Handb., U.S. Dep. Agric.*, No. 34, 1952, 23; Joshi, loc. cit.; Winton & Winton, I, 37; *Chem. Abstr.*, 1962, **56**, 3564; 1953, **47**, 7126).

Kudzu stalks yield 46.2 per cent of crude fibre. The fibre is extracted in China and Japan for the manufacture of cordage and a fabric known as grass-cloth which is favoured for summer wear (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 212; Thorpe, VII, 155; Matthews, 349; Joshi, loc. cit.; Porterfield, loc. cit.).

The starch of the roots is said to be official in the Japanese Pharmacopoeia. A decoction of the root is said to be used in China for ailments like colds, fever and dysentery. The flowers and the seeds are also used medicinally, and the shoots are used as lactagogue (Quisumbing, 427; Porterfield, loc. cit.).

Young leaves and shoots are reported to be edible. The extract of the vine is said to contain traces of a gibberellic acid-like substance (Terra, *Commun. R. trop. Inst. Amst.*, No. 54c, 1966, 70; Manzelli *et al.*, *Nature, Lond.*, 1962, **196**, 492).

P. phaseoloides Benth. syn. *P. javanica* Benth.
TROPICAL KUDZU

Fl. Br. Ind., II, 199 in part; Fl. Java, I, 632.

ASSAM—*Jermei-kyn-saw, jermei-soh-gonsoh.*

A woody twining climber clothed with dense spreading brown hairs, found from Kumaun to Assam along the sub-Himalayan regions up to an altitude of 1,100 m., and distributed further in Burma, Malaysia and China. Leaves trifoliolate: leaflets entire or lobed, densely pubescent on lower surface; flowers light lavender, often with whitish fringes, in long peduncled racemes 10-40 cm. long; pods 5-11 cm. long, pubescent, with 7-20 seeds.

Tropical kudzu is better adapted to tropical regions than kudzu (*P. lobata*). It thrives with a high and extended rainfall and withstands not too severe and prolonged dry season. It is not exacting in its soil requirements and grows well on heavy clay soils as well as on sandy loams. It tolerates a high water level in the soil. Because of its roots which penetrate deep into the soil, it can survive extended dry periods also. It endures conditions of partial shade when grown as a cover crop in plantations of rubber, citrus, coconuts, etc. (Whyte *et al.*, 318; Telford & Childers, *Circ. Fed. Exp. Sta. Puerto Rico*, No. 27, 1947).

Tropical kudzu has been tried successfully as a cover, green manure or forage crop in a number of tropical countries in South-East Asia, Equatorial Africa and Central and South America. In India, it has been tried in several areas, viz. Mysore, Coorg, Wynaad, Anaimalai hills and the ravine lands of

* According to Prain (*J. Asiat. Soc. Beng.*, 1897, **66**, 420), the specimens from Assam, North Bengal, Sikkim, Khasi and Naga hills referred to this species belong to *P. subspicata* Benth.

Indian Rubber Board

FIG. 117—PUERARIA PHASEOLOIDES—COVER CROP IN RUBBER PLANTATION

Uttar Pradesh [Telford & Childers, loc. cit.; Whyte *et al.*, 317; Use of Leguminous Plants, 238; Manual of Green Manuring, 68; Yegna Narayan Aiyer, 1950, 122; Nagasundara, *Indian Fmg, N.S.*, 1959–60, **9**(2), 33; Mudaliar, *Madras agric. J.*, 1953, **40**, 266; Kaushik, *Proc. 9th sylvic. Conf., Dehra Dun*, 1956, pt 1, 381].

Tropical kudzu is propagated by seeds and cuttings. The seeds must first be scarified by rubbing between two sheets of sand paper or by treating with concentrated sulphuric acid. In areas where seed setting is poor, cuttings 0.5 m. long can be used for planting. The plants grow rather slowly during the first 3–4 months and require special weeding and cultivation to accelerate their growth. Tropical kudzu can also be grown in pasture mixed with a suitable grass such as Guinea grass, but as the latter grows much quicker than tropical kudzu in the first few months, it may be necessary to graze the grass back to enable the kudzu crop to come up. Once tropical kudzu is established, it makes luxuriant growth and withstands even trampling fairly well. The plant is little affected by diseases or pests. It is reported to flower readily and to set seeds abundantly in some areas, while in other areas seed setting is poor. Seed production is better when the plants are allowed to climb or where there is a definite dry period than in areas where the rainfall is heavy (Yegna Narayan Aiyer, 1950, 124; Nagasundara, loc. cit.; Whyte *et al.*, 318; Telford & Childers, loc. cit.).

Cattle are said to graze readily on tropical kudzu, once they get accustomed to its taste. It is relished by work oxen, milch cows, goats and even poultry. It is estimated that about 0.4 hectare of tropical kudzu can feed one cow grazing continuously during the dry season and two cows during the rainy season. Care should be taken that the plants are not grazed down to the ground. Yields of 18 tonnes of green matter per hectare in three cuttings under rainfed conditions and 27 tonnes per hectare in 5–6 cuttings under irrigation have been reported from India, while higher yields up to 30–50 tonnes per hectare have been recorded elsewhere (Nagasundara, loc. cit.; Telford & Childers, loc. cit.).

Fresh leaves and stems of tropical kudzu have the following chemical composition and nutritive value: moisture, 80.9; protein, 3.8; fat, 0.4; soluble carbohydrates, 7.9; fibre, 5.5; ash, 1.5; calcium, 0.14; and phosphorus, 0.03%; digestible nutrients: protein, 2.9; fat, 0.2; and soluble carbohydrates, 6.5%; nutritive ratio, 3.5; and starch equivalent, 12.9 kg./100 kg. The green feed is rich in vitamin C, is a good source of vitamin A, and also contains B vitamins (Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 69, 77, 83).

Tropical kudzu forms an abundance of nitrogenous root nodules and affords a good green manure; the manurial constituents present are (dry matter basis): nitrogen, 1.8; calcium, 0.58; phosphorus, 0.24; and potassium, 1.13%. It is also very effective as a cover crop in plantations of rubber, cloves, citrus, coconut, etc. It is said to be ideal for erosion control (Use of Leguminous Plants, 238; Whyte *et al.*, 318; Pandalai *et al.*, *Indian Cocon. J.*, 1954–55, **8**, 32).

The tuberous root is said to be eaten in some parts of South-eastern Asia where it is abundant. A useful strong white fibre which can be made into twines and ropes is said to be extracted from the stem. The plant is said to be used medicinally for ulcers and boils in Malaya (Burkill, II, 1838; Fl. Assam, II, 82).

P. thomsonii Benth.

Fl. Br. Ind., II, 198.

Assam—*Suting, kaikuangru.*

A climber with slender branches clothed with

deciduous brownish hairs, found in North Bengal and in Khasi and Lushai hills in Assam. Leaflets green and sparsely hairy above and grey with dense, thin hairs beneath; racemes 15–22 cm. long with reddish coloured flowers; pods 10–12 cm. long, flat, straight, 8–12 seeded.

This species from Assam is held to be identical with *P. lobata* by some authors, but this view has not been accepted by most authorities. Hence, it is likely that some of the reports of trials with kudzu (*P. lobata*) from Assam possibly refer to *P. thomsonii* Benth. Under cultivation in Delhi it is said to have shown an average growth of 2.2 cm. per day and is not affected by low temperature [Prain, *J. Asiat. Soc. Beng.*, 1897, **66**, 419; Fl. Assam, II, 81; Gandhi, *Indian Fmg, N.S.*, 1954–55, **4**(10), 26].

Cattle are said to browse upon this plant. In Indo-China, this species is reported to be cultivated. The tubers are considered edible (Fl. Assam, II, 81; Mansfeld, 213).

P. tuberosa DC. INDIAN KUDZU

D.E.P., VI(1), 363; Fl. Br. Ind., II, 197.

HINDI—*Sural, bilaikand, bharda, tirra, bankumra*; BENG.—*Shimia batraji*; MAR.—*Ghorbel*; GUJ.—*Vidarikand, phagvelo, khakarvel*; TEL.—*Darigummadi*; KAN.—*Gumadigida*.

PUNJAB—*Siali*; KUMAUN—*Sirala, bisalu*.

A large perennial climber with very large tuberous roots, distributed nearly throughout India, except in very humid or very arid regions, and ascending up to 1,200 m. Stems woody, up to 12 cm. in diam., leaves trifoliolate; flowers blue or purplish blue, in racemes 15–30 cm. long; pods flat, 5–7 cm. long; densely clothed with long, silky, bristly brown hairs; seeds 3–6.

P. tuberosa can be called the Indian Kudzu by virtue of the many characters which it shares in common with kudzu and tropical kudzu. It is said to be rather very common in some areas and is an extremely prominent vine in exposed and eroded areas, covering the ground, bushes, and even large trees. In a comparative study of the merits of *P. lobata* (kudzu), *P. phaseoloides* (tropical kudzu) and *P. tuberosa* (Indian kudzu) for suitability of soil-erosion control in Punjab, western Uttar Pradesh and Central India, it was found that only *P. tuberosa* was suitable for this purpose. It was quite satisfactory from the points of soil binding, soil cover and restoration of soil fertility. The plant can be easily propagated from seeds and crowns, the production of seeds being prolific. The green foliage and tender twigs are as nutritious and palatable as those of kudzu, and a yield of 7.5 to 10.0 tonnes of air-dry foliage per hectare has been reported (Kaushik, *Proc. 9th sylvic. Conf., Dehra Dun*, 1956, pt 1, 381; Rao, *Indian For.*, 1958, **84**, 281).

The tubers are large, 30–60 cm. long and 25–30 cm. broad, weighing up to 35 kg. They are often found in strings connected with the main roots by thin roots. The yield of tubers is reported to be about 5.0 to 7.5 tonnes per hectare. They taste like liquorice and are said to be eaten raw or boiled. They are often fed to horses and ponies. The tubers can be used for the extraction of starch. They contain: dry matter, 85.1; total carbohydrates, 64.6; crude fibre, 28.4; crude protein, 10.9; and ether extr., 0.5%. β-Sitosterol, sucrose, glucose and fructose have been identified. The extract of tubers is active against *Helminthosporium sativum* Pamm., King & Bakke (Fl. Assam, II, 80; Haines, III, 281; Atal & Qadry, *J. sci. industr.*

FIG. 118—PUERARIA TUBEROSA—FLOWERING AND FRUITING BRANCH

Res., 1962, **21C**, 184 ; Rao, loc. cit. ; Kaushik, loc. cit. ; Anjaneyulu *et al.*, *Indian J. Chem.*, 1965, **3**, 237 ; Lakhera, *Curr. Sci.*, 1965, **34**, 249 ; Bhatnagar *et al.*, *Indian J. med. Res.*, 1961, **49**, 799).

The leaves of *P. tuberosa* afford good fodder for horses and cattle. Analysis of the dry leaves gave: crude protein, 23.8 ; fat, 0.7 ; crude fibre, 30.7 ; other carbohydrates, 31.6 ; ash, 12.0 ; calcium, 1.6 ; and phosphorus, 0.2% (Rao, loc. cit.).

The roots are said to be used in medicine as a demulcent and refrigerant in fevers, as cataplasm for swellings of joints, and as lactagogue. The dried roots are sold as drug in the form of longitudinally cut, decorticated flat thin slices of a white to dirty white colour with a slight characteristic odour and peculiar sweet taste (Kirt. & Basu, I, 792 ; Atal & Qadry, loc. cit.).

Puffball — *see* **Fungi**

PULICARIA Gaertn. (*Compositae*)

A genus of annual or perennial herbs distributed in Asia, Europe and Africa. Eight species are recorded in India.

P. crispa Oliver

D.E.P., VI(1), 364 ; Fl. Br. Ind., III, 299 ; Kirt. & Basu, Pl. 526A.

HINDI—*Burhna*.

PUNJAB—*Bui, gidi, phatmer, sutei* ; DELHI—*Haldwa* ; RAJASTHAN—*Dhola lizru*.

A shrubby perennial, 30–60 cm. high, found in Punjab, upper Gangetic plain, Bihar, Gujarat and Rajasthan. Leaves linear oblong, undulate-crisped ; heads solitary, yellow ; achenes oblong.

The dried herb is applied as a vulnerary to bruises and sores of bullocks. A decoction of the plant is taken for febrile conditions. In Sahara, the plant is used as a substitute for tea (Kirt. & Basu, II, 1354 ; Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41**, 854 ; Dalziel, 419).

P. dysenterica Bernh.

Fl. Br. Ind., III, 298.

A perennial herb, about 60 cm. high, found in Kashmir at altitudes of 1,500–1,800 m. Leaves oblong-cordate, wavy and toothed ; heads a dense, woolly, yellow corymb ; achenes silky.

The plant, on extraction with volatile solvents, yields 0.27 per cent of a pale green concrete, from which, on further treatment, 78 per cent of an absolute can be obtained. The absolute has the following constants: sp. gr.$^{15°}$, 0.8976 ; $[\alpha]_D^{15°}$, $-3.7°$; and $n_D^{20°}$, 1.5230. It consists principally of terpenes (myrcene, styrolene, traces of camphene, limonene) and borneol ; cineole, eugenol, dimethyl phloracetophenone, and methyl and *iso*butyl phlorol are also reported to be present. The plant also contains inulin (Salgues, *Qualit. Plant. Mat. Veg.*, 1952–54, **1**, 139 ; Wehmer, II, 1219).

The plant possesses tonic, astringent and diuretic properties, and is used as remedy for dysentery and diarrhoea (Steinmetz, 1957, 586).

P. foliolosa DC. is a much-branched annual, 30–60 cm. high, with linear-oblong or oblanceolate leaves found in upper and lower Gangetic plains, Sikkim, North Bengal, Orissa, Konkan, Deccan and Madhya Pradesh. The plant, where it is sufficiently abundant, is used as fodder for camels (Duthie, I, 465).

Pummelo — *see* **Citrus**

Pumpkin — *see* **Cucurbita**

PUNICA Linn. (*Lythraceae* ; *Punicaceae**)

A genus of large shrubs or small trees with 2 species, one, *P. protopunica* Balf. f., found wild in Socotra Islands and the other, *P. granatum*, cultivated in tropical and sub-tropical parts of the world for its fruits.

P. granatum Linn. POMEGRANATE

D.E.P., VI(1), 368 ; C.P., 909 ; Fl. Br. Ind., II, 580 ; Fl. Malesiana, Ser. I, **4**(3), 226–27, Fig.

HINDI—*Anar* ; BENG.—*Dalim* ; MAR.—*Dalimba* ; GUJ.—*Dadam* ; TEL.—*Danimma* ; TAM.—*Madulai* ; KAN.—*Dalimba* ; MAL.—*Matalam*.

A shrub or small tree, 5–10 m. high, considered to be a native of Iran, Afghanistan and Baluchistan, found growing wild in the warm valleys and outer hills of the Himalayas between 900 and 1,800 m. and cultivated throughout India. Bark smooth, dark grey ; branchlets sometimes spiniscent ; leaves 2.0–8.0 cm. long, oblong or obovate, shining above ; flowers usually scarlet red, sometimes yellow, 3.7–5.0 cm. long and as much across, mostly solitary or 2–4 together ; fruits globose, crowned by persistent calyx, with a coriaceous woody rind and an interior septate with membranous walls, containing numerous seeds ; seeds angular with a fleshy testa which is red, pink or whitish.

*On the basis of the structure of the ovary and the typical fruit (the balusta), *Punica* has been classified as the solitary genus under a separate family *Punicaceae*, distinct from *Lythraceae*, though many authors still continue to treat the genus as a member of *Lythraceae*.

The pomegranate is a fruit of great antiquity and is known to have been cultivated in the Middle East more than 5,000 years ago. The wild or semi-wild pomegranate still exists in the north of Syria, in Gilead and on Mount Carmel. It is also found in various regions from Caucasus to Afghanistan, the wild types of Central Asia showing a wide range of variation in the size of the fruit, sweetness, time of ripening, juiciness and proportion of seeds to flesh. According to De Candolle, Vavilov and others, the pomegranate originated in South-West Asia, probably in Iran and some adjoining countries [Burkill, II, 1839; Fl. Malesiana, Ser. I, **4**(3), 226; Zukovskij, 60; Goor, *Econ. Bot.*, 1967, **21**, 215].

Punica granatum has been classified into two sub-species, *chlorocarpa* and *porphyrocarpa*, each having two varieties. These sub-species have been established on the basis of the colouring of the ovary, a stable feature which is retained when they are reproduced by seeds. Sub-species *chlorocarpa* is mainly found in the Transcaucasus, whereas the second, *porphyrocarpa* is mainly Central Asian in distribution [Rozanov, *Izv. Akad. Nauk. tadzh. SSR*, 1963, **2**(13), 35].

Though mostly found cultivated in many parts of India, the tree is also very common and gregarious in the gravel and boulder deposits of dry ravines and similar places in the outer Himalayas, up to about 1,800 m. In Jammu, it is found growing gregariously on dry limestone soils in the upper extremities of sub-tropical forests; it is also found in Chamba, Kangra and Mandi districts of Himachal Pradesh and valleys below 1,800 m. in Jaunsar and Tehri-Garhwal districts of Uttar Pradesh (Troup, II, 610; Information from Director of Agriculture, Uttar Pradesh, and Y. K. Sarin, Regional Research Laboratory, Jammu; Gupta, 248).

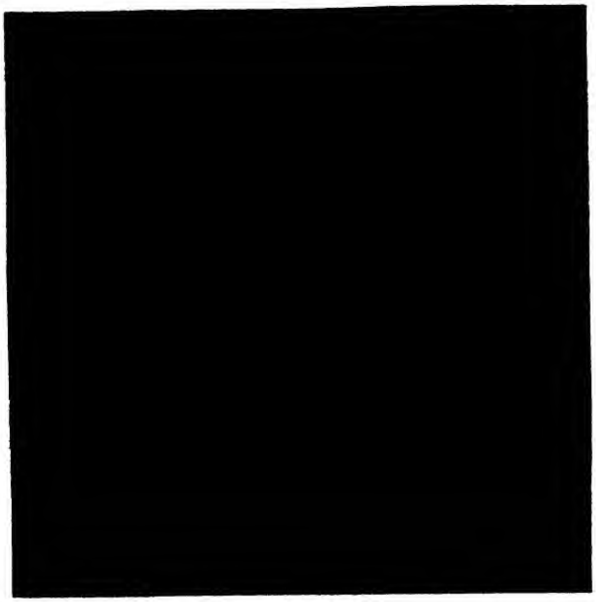
As a cultivated crop, the pomegranate is grown to a limited extent in selected localities in almost all States. Maximum area is said to be devoted to it in Maharashtra, particularly in Poona, Sholapur and Satara districts. In Gujarat, its cultivation is concentrated in Dholka taluk. It is cultivated in the districts of Almora, Aligarh, Tehri-Garhwal, Meerut and Farrukhabad in Uttar Pradesh; Uthukuli, Michaelpatti, Vellodu and Dindigul in Madras State; Penukonda and Madakasira in Andhra Pradesh; Tumkur, Kolar, Bangalore and Mysore districts in Mysore State (Cheema *et al.*, 270; Naik, 390; Information from Directors of Agriculture, Madras and Mysore).

Several types of pomegranate are cultivated in India, distinguished by the shape of the fruit, the colour and thickness of rind, and the taste and colour of the seeds. The fruits are round, oblate or obovate in shape and vary in diameter from 8 to 12 cm. The rind may be thick or thin, the colour varying from pale yellow to crimson. The seed pulp in superior types is thick, fleshy and very juicy, while in inferior types it is thin. It ranges in colour from white and transparent in some to pink and blood red in others; the pulp taste also varies from sweet and aromatic to sour and insipid. The seed coat varies in hardness, some of the softer seeded types being known as seedless (*Bedana*). Lack of lignification of the testa (outer integument) is the main cause of so called seedlessness in pomegranate. Among the numerous types grown, the *Bedana* and *Kandahari* are considered the best. Table 1 gives the different types of pomegranate grown in India (Naik, 390; Hayes, 404; Gopalaswamiengar, 608; Nath & Randhawa, *Indian J. Hort.*, 1959, **16**, 191; Kihara in Yamashita, 287).

TABLE 1—TYPES OF POMEGRANATE GROWN IN INDIA*

Type	Fruit characters
Alandi or Vadki	Fruit medium in size; fleshy testa blood red or deep pink, with sweet, slightly acidic juice; seeds very hard
Bedana	Fruit medium to large in size; rind brownish or whitish; fleshy testa pinkish white, with sweet juice; seeds soft
Dholka	Fruit large in size; rind greenish white; fleshy testa pinkish white or whitish, with sweet juice; seeds soft
Kabul	Fruit large in size; rind deep red mixed with pale yellow, thick; fleshy testa dark red, with slightly bitter juice
Kandahari	Fruit large in size; rind deep red; fleshy testa blood red or deep pink, with sweet, slightly acidic juice; seeds hard
Musket Red	Fruit small to medium in size; rind somewhat thick; fleshy testa with moderately sweet juice; seeds not very hard
Paper Shell	Fruit medium in size; rind thick; fleshy testa reddish to pink, with sweet juice; seeds soft
Poona	Fruit large in size; rind crimson, dark grey or greyish green, sometimes variously spotted; fleshy testa deep scarlet or pink and red
Spanish Ruby	Fruit small to medium in size; rind thin; fleshy testa rose coloured; seeds soft
Vellodu	Fruit medium to large in size; rind moderately thick; fleshy testa juicy; seeds moderately hard

* Gammie & Patwardhan, *Bull. Dep. Agric. Bombay*, No. 30, 1908, 521; Thapar, 147; Naik, 391; Cheema *et al.*, 272.



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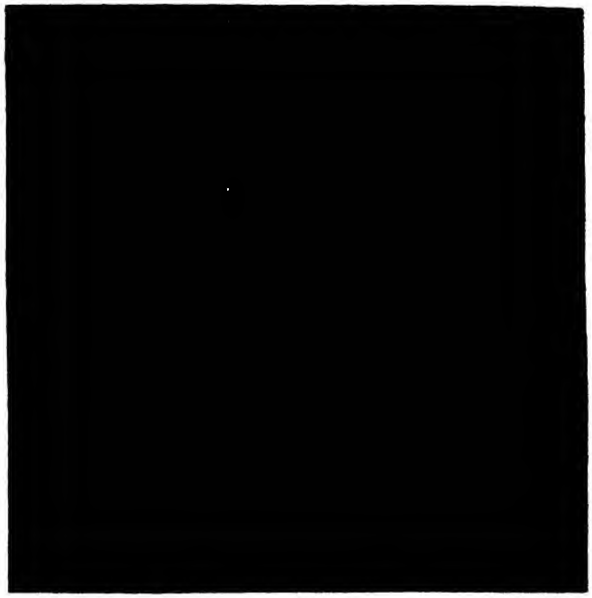

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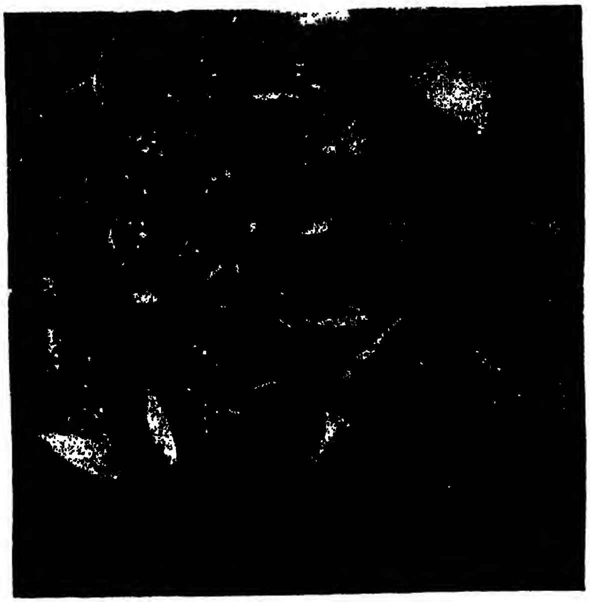


3

4

PUNICA GRANATUM

1, Flowering and Fruiting Branch (Red-Flowered); 2, Flowering and Fruiting Branch (Yellow-Flowered); 3, 4, Fruits showing the Pulpy Seeds

Besides those grown for fruit, there are a few ornamental types planted in gardens, some of them horticulturally named as distinct forms. A dwarf type and a double-flowered form with red, yellow or white flowers are the most popular (Bailey, 1947, III, 2751; Rehder, 667; Firminger, 519; Gopalaswamiengar, 284).

Cultivation

Climate and Soil—The pomegranate is a subtropical fruit tree, growing best in semi-arid climate where cool winters and hot summers prevail. It grows under a wide range of climatic conditions and is planted up to 35°N in U.S.A. It stands considerable frost, and is injured only when the temperature goes below −11°. It thrives even under desert conditions. Although it is highly drought-resistant, the pomegranate bears well only under irrigation (Gopalaswamiengar, 607; Ochse *et al.*, I, 720; Hayes, 403; Thapar, 146).

The pomegranate gives very good returns in a deep loamy soil although it thrives well on comparatively poor soils where other fruits fail to flourish. It shows a preference to calcareous soil containing lime nodules and tolerates soil alkalinity to a greater extent than most other plants (Hayes, 403; Thapar, 146; Venkataratnam, 120).

Propagation and Culture—The pomegranate is propagated by seed in Bombay, Gujarat and in South India, although the universal method of propagation is by hard wood cuttings. Propagation by seedlings leads to wide differences in tree and fruit characters. Vegetative propagation is found to be more dependable for preserving and multiplying the selected types. When vegetatively propagated, hard wood cuttings, 25–50 cm. long, from the previous season's growth are taken. These are planted in beds leaving only one or two buds exposed. A year after, the rooted cuttings are lifted out with a ball of earth around their roots and transplanted to the orchard (Hayes, 403; Naik, 391).

In the generally poor soils of Deccan, the plants are given a spacing of 3.5–4.5 m. In lighter but deeper soils the distance is increased to 5.5 m. Pits of 60 cm.×60 cm.×60 cm. are dug at the required distance and filled with about 20 kg. of farmyard manure mixed with fine soil. Seedlings or cuttings are planted in these pits (Cheema *et al.*, 274).

Manuring—Well-rotted, old farmyard manure, mixed with ashes, is usually applied to pomegranate plants at the rate of about 20 kg. per seedling, while planting. After this 3–6 baskets of old cattle manure is given to each plant every year at the break of the monsoon. When the fruits are fairly well developed an application of 2.0–2.5 kg. of groundnut cake is advantageous. Application of small quantities of ammonium sulphate, wood ash and lime along with farmyard manure is also recommended [Cheema *et al.*, 275; Katyal & Chadha, *Fertil. News*, 1962, **7**(4), 25].

Irrigation—Pomegranate responds well to irrigation. In Gujarat and Maharashtra, the bed or basin system of irrigation is practised. In this, small round basins are made at the base of each tree and these are filled with water. Monsoon showers are supplemented by irrigation during May and June. Copious and regular irrigation is essential during fruiting season, as irregular moisture conditions result in the cracking of fruits (Cheema *et al.*, 275).

Pruning—Pomegranate does not usually require pruning except for removing the suckers and giving a shape to the tree. The tree should be allowed to grow a clean main stem by pruning the side branches. Fruits are borne terminally on short spurs emerging from mature wood. Every year the bearing region is pushed farther away from the base. The interior of the plant also becomes devoid of fruits. For securing shapely trees and getting a good crop, a set of new shoots should be allowed to grow every year on all sides of the tree. The pruning should be confined to a shortening of the past season's growth (Cheema *et al.*, 275; Naik, 391–92).

Diseases and Pests—The fruits are subject to fruit rot especially during the rainy season. They get soft in some portions and rot. Fruit rot can be controlled by spraying with Bordeaux mixture (Venkataratnam, 123).

In Punjab, pomegranate suffers from the dieback of twigs, caused by *Pleuroplaconema punicae* Petrak. *Aspergillus castaneus* Patterson causes discolouration of the fruits and seeds, while in Mysore a disfigurement of the fruits is caused by *Sphaceloma punicae*. A dry rot of pomegranate fruits caused by *Phomopsis* sp. resulted in 80 per cent loss of fruits in Bulandshahr district (Uttar Pradesh) in 1950. Spraying Perenox with Albolinium sticker reduces the fruit rot to a manageable extent. Dry rot of the fruits caused by *Zythia versoniana* Sacc. can be greatly reduced by spraying with Bordeaux mixture (Nirvan, *Sci. & Cult.*, 1956–57, **22**, 395; Mehta, *Plant Prot. Bull., New Delhi*, 1951, **3**, 7; *Chem. Abstr.*, 1940, **34**, 5110).

Other minor diseases are leaf and fruit spot caused by species of *Cercospora* and *Gloeosporium* which can be controlled by spraying with Bordeaux mixture. Besides these, canker and dieback caused by *Ceuthospora phyllosticta*, and leaf spot caused by *Pestalotia* sp. have also been reported [Hayes, 405; *Hort. Abstr.*, 1966, **36**, 637].

The most common pest of pomegranate is the fruit borer, which is the grub of the pomegranate butterfly *Virachola isocrates* Fb. The butterfly lays eggs on flower buds and the calyx cup of the developing fruits. The eggs hatch out in about 5–7 days and the caterpillars bore through the calyx cup and enter the fruits. Sometimes the entire crop may get affected by the borers, with considerable loss to the grower. This insect can be controlled by periodically spraying the plants with Endrin on the developing flowers. Two sprayings done at monthly intervals will keep the borer away [Srivastava, *Indian Fmg, N.S.*, 1960-61, **10**(1), 9].

Paper bags, plastic covers, wire cages and tin cases are also used to protect the developing fruits. These covers protect the crop from the borer, as well as from birds, bats and squirrels [Gopalaswamiengar, 610; Srivastava, *Gardening*, 1956–59, **1**(2), 41].

The stem borer is another common insect found in neglected orchards. The caterpillar makes a hole and bores through the branches. The hole can be cleaned and petrol inserted into it by means of a cotton plug. The petrol vapours kill the insect (Venkataratnam, 122–23).

Besides loss caused by pests and diseases, considerable damage is done to the crop by the cracking of fruits. This is caused by unequal moisture content of the soil. It is not known whether any causal organism is also associated with the cracking. Adequate and regular irrigation and interculture throughout the bearing period may reduce cracking (Cheema *et al.*, 279).

Harvesting and Yield—Normally, the pomegranate starts fruiting in about 4 years after transplantation. Fruits ripen in about 6–7 months from the time of flowering. According to seasonal changes, there are three flowering seasons in Deccan, viz. June–July (*Mrig bahar*) coinciding with the break of monsoons, February–March (*Ambe bahar*) and September (*Hatti bahar*). Although the pomegranate may be induced to bear fruit in any of the seasons, the usual harvesting season is October–December [Cheema *et al.*, 277; Pandit *et al.*, *Indian Fd Packer*, 1960, **14**(4), 16].

The fruits are harvested when the skin turns slightly yellow and the fruit gives out a metallic sound when tapped. Each tree bears about 100 fruits. In Bombay, trees bearing up to 200 fruits have been recorded. The harvested fruits can be stored for a few weeks and actually they improve on keeping. The fruits are wrapped in paper and sent in bamboo baskets of 50–60 fruits to the city markets (Venkataratnam, 122).

Storage—Pomegranates keep well for a long time. Experimental trials showed that fruits stored at 0° and 4.5° at 80–85 per cent R.H. did not undergo any shrinkage or spoilage for seven months. They may be sprayed with a 2 per cent Lypol solution and aerated properly before using. In bulk storage, they are packed in layers in wooden crates each containing 16–18 kg. of fruits and stored at 0° and 80 per cent R.H. Rice straw and paper are used as packing material (Mukerjee, *Sci. & Cult.*, 1958 59, **24**, 94; *Food Sci.*, 1959, **8**, 130).

Trade—Pomegranates are imported into India mainly from Afghanistan and West Pakistan. In 1965 66, 155,000 kg. of fruit worth Rs. 177,000 was imported from Afghanistan, while 35,000 kg. of the fruit worth Rs. 14,000 was imported from West Pakistan. In 1966–67, there was a sharp decline in imports with 1,053 kg. of fruit worth Rs. 1,243 being imported from Afghanistan while imports from West Pakistan ceased altogether. Exports of the fruit from India to Nepal and other countries during 1965–66 and 1966 67 amounted to 4,216 kg. worth Rs. 21,574 and 3,853 kg. worth Rs. 8,345, respectively.

Utilization and Chemical Composition

Pomegranate is largely used as a dessert. The seeds along with the fleshy portions are dried and commercially marketed as *Anardana* and are widely used as condiment. The source of *anardana* of commerce is said to be the wild trees, covering vast tracts of hill slopes in Jammu, and parts of Chamba, Kangra and Mandi districts of Himachal Pradesh, and Punjab. The main areas from where *anardana* is collected are the Riasu, Udhampur, Ramban, Kishtwar and Bhadarwah Forest Divisions. In these areas, fruits are hand-picked towards the middle of October, when they are ripe and brown red in colour. Seeds with the pulp are separated by hand from the rind and are dried in the sun for about 10–15 days when the colour of the seeds turns reddish brown. The main assembling centre for *anardana* is Udhampur from where distribution is done all over the country. About 350 tonnes of *anardana* are reported to have been marketed from

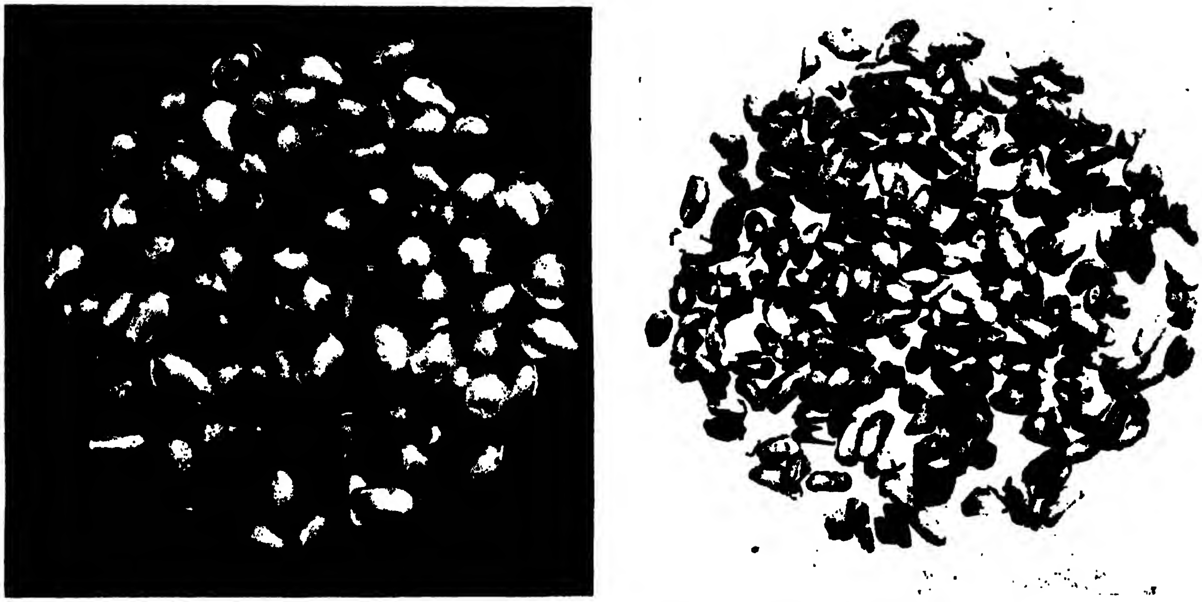


FIG. 119—PUNICA GRANATUM—SEEDS, FRESH AND DRIED (ANARDANA)

Udhampur in 1963-64 (Sarin, *Indian For.*, 1965, **91,** 559: Information from Shri Y. K. Sarin, Regional Research Laboratory, Jammu).

Analysis of the edible portion (68%) of pomegranates from Coonoor gave: moisture, 78.0; protein, 1.6; fat, 0.1; fibre, 5.1; other carbohydrates, 14.5; and mineral matter, 0.7%; calcium, 10: magnesium, 12: oxalic acid, 14; phosphorus, 70.0; iron, 0.3; sodium, 0.9; potassium, 133.0; copper, 0.2; sulphur, 12.0; chlorine, 2.0: carotene, 0; thiamine, 0.06; riboflavin, 0.10; nicotinic acid, 0.30; and vitamin C, 14 mg./100 g. The fruit is a good source of sugars and vitamin C, and a fair source of iron but is poor in calcium. The sugar content increases with the age of the fruit and of the tree. The fruit contains 0.27 per cent of pectin (as calcium pectate). During ripening, the insoluble pectin changes into soluble pectin. The concentration of vitamin C is said to increase with maturity and ripening of the fruit, and in most cases the maximum amount is observed in the nearly ripe fruit (Nutritive Value of Indian Foods, 73, 108, 137; Brown, 1946, III, 51; *Chem. Abstr.*, 1960, **54,** 13484; Trehan & Ahmad, *J. sci. industr. Res.*, 1947, **6B,** 16; Gonzalez *et al., Philipp. J. Sci.*, 1963, **92,** 17; Sinha, *Indian J. appl. Chem.*, 1959, **22,** 32).

A delicious juice is prepared from the fruits. Fully ripe fruits yield a sweet, deep-coloured juice with a rich flavour. For obtaining the juice, the fruits are cut into quarters and pressed under moderate pressure in a rack and cloth hydraulic press (yield 360–405 litres/tonne of fruits). According to another process, the grains may be separated from the quarters and processed in a basket press, but this way the juice recovery is considerably less. The extraction of the juice may also be carried out by pressing the whole fruit, without crushing or other previous treatment. The excess of dissolved tannin in the juice arising from the fruit rind can be precipitated out by the addition of a suitable quantity of gelatin solution. The juice after filtration is clarified by heating in a flash pasteurizer to 79–82°, cooling at once, settling for 24 hours, racking and filtering. It is preserved either by pasteurization or by addition of sodium benzoate. The preserved juice has an excellent keeping quality (Siddappa, *Indian Fmg*, 1943, **4,** 196; Tressler & Joslyn, 712-13; Girdhari Lal *et al.*, 131; Cruess, 384).

The quality of pomegranate juice is determined to a great extent by its acid and sugar contents. The acidity of the juice is reported to vary from 0.45 to 3.47 g./100 ml. and the reducing sugars from 7.8 to 13.7 g./100 ml. The juice extracted from some types of pomegranates grown in Maharashtra contained 0.37–0.78 per cent of acids and 5.1–14.6 per cent of reducing sugars. Fruits of the *Kandahari* type produce a purplish red juice with a mildly acid-sweet taste; analysis of a sample gave: acid (as citric), 0.81–1.23; tannin in juice from whole fruit, 0.17;

and tannin in juice from grains, 0.12%. Glucose and fructose are the principal sugars in pomegranate juice, whereas sucrose is usually absent; maltose is also reported. The acids consist primarily of citric (*c.* 95% of the total acids), with malic as the minor component. Among the amino acids, aspartic acid and glutamine have been identified in the juice (Hayes, 404; Winton & Winton, II, 802; Nadkarni, I, 1032; Siddappa, loc. cit.; Siddappa & Bhatia, *Indian J. Hort.*, 1954, **11**, 19; Srivastava, *J. sci. industr. Res.*, 1953, **12B**, 363; Rao *et al.*, ibid., 1956, **15C**, 39; Kalyankar *et al.*, *Curr. Sci.*, 1952, **21**, 220).

Pomegranate juice blends well with other juices. Because of high acidity, its palatability is greatly improved after sweetening. It finds use in the preparation of true granadine, but the commercial beverage is mostly of synthetic origin. Pomegranate juice may be converted into an excellent syrup. *Anar rub* is a product locally prepared from the juice by adding sugar and heating to a thick, viscous consistency (total solids, 70–75%). It keeps well and is used like tomato sauce or ketchup (Tressler & Joslyn, 713; Winton & Winton, II, 799; Siddappa, loc. cit.).

The fruit juice easily ferments and may be used for the production of wines. The juice of the wild pomegranates in Azerbaijan (U.S.S.R.) is used in the manufacture of citric acid and sodium citrate for medicinal use (Jacobs, III, 2400; *Chem. Abstr.*, 1950, **44**, 2181; 1959, **53**, 17483; 1944, **38**, 5359).

The seeds (minus juicy coat) contain: moisture, 35.0; fat, 6.9; nitrogenous substances, 9.4; starch, 12.6; crude fibre, 22.4; and ash, 1.5%. Estrone has been reported in the seeds (1.7 mg./100 g.). The seeds yield a drying oil (iod. val., 163) which contains punicic acid forming up to 72 per cent of the fatty acids. Punicic acid is conjugated triene and a geometrical isomer of elaeostearic acid. The oil possesses antibacterial properties (Wehmer, II, 817; Heftmann *et al.*, *Phytochemistry*, 1966, **5**, 1337; Hilditch, 1956, 205, 535; Earle *et al.*, *J. Amer. Oil Chem. Soc.*, 1960, **37**, 440; Ahlers & Mc Taggart, *J. Sci. Fd Agric.*, 1954, **5**, 75; Chopra *et al.*, *J. Amer. pharm. Ass., sci. Edn*, 1960, **49**, 780).

The fresh rind of the fruit contains: wax, 0.8; resins, 4.5; mannitol, 1.8; non-crystallized sugars, 2.7; gums, 3.2; inulin, 1.0; mucilage, 0.6; tannin, 10.4; gallic acid, 4.0; and calcium oxalate, 4.0%. Pectin occurs to the extent of 2–4 per cent (Thorpe, X, 128; *Chem. Abstr.*, 1958, **52**, 14027).

Tannin occurs in all parts of the tree, particularly in fruit rind (up to 26% in dried rind), stem bark (10–25%), root bark (28%), and leaves (11%). The fruit rind and the bark of the stem and root have been widely used as tanning materials from early times in the Mediterranean countries and the East. The bark was once much used for production of Morocco leather. The leaves may also be employed for tanning (Howes, 1953, 285; *Chem. Abstr.*, 1942, **36**, 2438).

The fruit rind constitutes one of the important tanning materials in Jammu and Kashmir State, where it is obtained as a by-product of *anardana* prepared from wild fruits. Its annual availability in the State is estimated at 40,000 kg. The dried rind contains: moisture, 8–14; tannins, 18–22; and soluble non-tannins, 16–23%. The tannin is of the myrobalan type. Solid tan extract (yield, *c.* 55% of the rind) prepared by aqueous extraction of the rind is dark brownish black in colour and contains: total tannins, 32.8; hydrolysable tannins, 22.1; sugars, 10.1; and ash, 11.3%. In laboratory trials, the rind extract either alone or in blend (1:2) with *Acacia arabica* bark extract (containing *c.* 42% tannin) produced leather which was smooth and did not show tendency to crack. The leather tanned with pure rind extract was rather soft, and had slight greenish brown appearance whereas the blend produced a satisfactory leather with a light grey colour. When tried as a substitute for myrobalan, the pomegranate extract produced a darker leather and had to be given a chemical pretreatment (Sarin & Kapoor, *Bull. reg. Res. Lab., Jammu*, 1963, **1**, 136; Sharma & Rao, *Res. & Ind.*, 1962, **7**, 212; Kedlaya *et al.*, *Leath. Sci.*, 1963, **10**, 305; Kedlaya & Selvarangan, *Bull. cent. Leath. Res. Inst., Madras*, 1961–62, **8**, 434).

The rind of pomegranate is also the source of a dye which gives yellowish brown to khaki shades and has been used for dyeing wool and silk. It is largely employed to dye wool in Almora district (Uttar Pradesh). The rind extract has been tried as a substitute for basic dyestuffs in the dyeing of jute, but the results have been unsatisfactory (Shroff & Trivedi, *Bull. Dep. Ind. Comm., United Provinces, N.S.*, No. 8, 1940, 7; Saha, *J. Indian chem. Soc., industr. Edn*, 1950, **13**, 235).

The flowers yield a light red dye said to have been used in India for dyeing cloth. They contain the pigment pelargonidin 3,5-diglucoside. The pigment in the edible portion of the fruits of Californian origin is reported to be delphinidin diglycoside. Examination of a type of pomegranate from Delhi showed the presence of malvidin pentose glycoside in the juice,

and a mixture of pentose glycosides (malvidin derivative along with some petunidin derivative) in the rind. The rind also contains *iso*quercetrin (Harborne, *Phytochemistry*, 1963, **2**, 85; Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B**, 605; Sharma & Seshadri, ibid., 1955, **14B**, 211; Rajadurai *et al.*, *Leath. Sci.*, 1963, **10**, 141).

The bark of the stem and root contains a number of alkaloids belonging to the pyridine group. The proportion of total alkaloids in different samples varies widely, ranging from 0.3 to 0.6 per cent in root bark. The alkaloid content of root samples from Poona was as follows: fresh bark of young roots, 0.38; fresh bark of old roots, 0.44; and fresh wood of young roots, 0.11%. Fresh root contained higher amounts of alkaloids than the stored root (U.S.D., 1955, 1798; Chilton & Partridge, *J. Pharm., Lond.*, 1950, **2**, 784).

The following alkaloids have been reported as occurring in the bark: pelletierine ($C_8H_{15}ON$, b.p./21 mm., 106°), *iso*pelletierine [α-(2-piperidyl)-propan-β-one, $C_8H_{15}ON$, b.p./11 mm., 102–07°], pseudopelletierine ($C_9H_{15}ON$, m.p. 53–54°), methyl pelletierine ($C_9H_{17}ON$, b.p./45 mm., 106–08°), and methyl *iso*pelletierine [α-(2-N-methylpiperidyl)-propan-β-one, $C_9H_{17}ON$, b.p./26 mm., 114–17°]. Of these, only *iso*-, methyl *iso*-, and pseudo-pelletierines have been synthesized. Later work showed that pelletierine, which was earlier assigned the structure of β-(2-piperidyl)-propanol, is identical with *iso*pelletierine and that methyl pelletierine is probably the same as methyl *iso*pelletierine. According to a more recent investigation, the bark contains, besides the *iso*-, methyl *iso*-, and pseudo-pelletierines, new bases designated A_0, A_1 ($C_9H_{17}O_2N$), A_2 ($C_{10}H_{19}O_2N$), A_3 and A_4 (C_7H_9ON); bases A_0 and A_3 are possibly artefacts. A sample of the bark from Egypt was free of alkaloids (Henry, 55–58; Manske & Holmes, I, 176–80; VI, 125–26; *Chem. Abstr.*, 1961, **55**, 12414; 1964, **61**, 6046).

The dried bark, of both the root and stem, has long been used in the treatment of tapeworms. The active principles are the alkaloids of which *iso*pelletierine is the most potent as taenicide. The bark is used usually in the form of a decoction. The tannate of alkaloids, known as Pelletierine Tannate, is however considered to be the most effective and least harmful form of the remedy because of its insolubility which prevents its rapid absorption and thus enables a prolonged contact with the worms. For its preparation, the ground bark is mixed with lime and extracted with chloroform. After conversion of the alkaloids to sulphate and solution in water, they are precipitated by tannic acid as tannates. Pelletierine tannate is a mixture with varying proportions of tannates of the bark alkaloids, and should contain the amount of alkaloids equivalent to not less than 20 per cent as hydrochloride. Commercial drug is highly variable in its alkaloid content and may not contain the active constituents in adequate amounts (U.S.D., 1955, 1798; *Chem. Abstr.*, 1957, **51**, 11364; Chilton & Partridge, loc. cit.; Claus, 1961, 299).

In sufficient dose, *iso*pelletierine (pelletierine of literature) produces complete paralysis; pharmacological studies by different investigators have given highly divergent results as to its mode of action. The chief symptoms from overdoses of the decoction of the bark or pelletierine are muscular weakness and sometimes dizziness. Excessive doses produce mydriasis, amblyopia, vomiting, diarrhoea, and extensive muscular weakness, followed by paralysis (U.S.D., 1955, 1798; Chopra *et al.*, I, 394–95).

A process for the production of an insecticidal preparation from the bark has been patented in Japan; the product includes the alkaloids and their tannates. D-Mannitol occurs abundantly in the stem bark and in lesser amounts in root bark, seeds, and leaves; biological tests indicate that mannitol possesses mild antispasmodic and anthelmintic properties. Friedelin and betulic acid are reported in the bark, betulic and ursolic acids in the leaves, and ursolic acid in the fruit rind. Leaves of young plants contain an unstable alkaloid [$C_8H_{13}N$: 2-(2-propenyl)-Δ'-piperideine, m.p. of hydrochloride 112–14°] (*Chem. Abstr.*, 1953, **47**, 1890; 1964, **61**, 6046; 1955, **49**, 5782; Roberts *et al.*, *Phytochemistry*, 1967, **6**, 711).

Extracts of different parts of the tree exhibited antibiotic activity. Extracts of the whole fruit were highly active against *Micrococcus pyogenes* var. *aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. They were also very effective against intestinal pathogenic bacilli such as *Salmonella typhosa*, *S. montevideo*, *S. schottmuelleri*, *Shigella paradysenteriae* B.H. and *S. paradysenteriae III-Z*. Alcoholic extracts of the fruit rind and root bark showed activity against *Micrococcus pyogenes* var. *aureus*. Aqueous extract of the root was found to inhibit completely the activity of *Mycobacterium tuberculosis* 607. The leaf and fruit gave a positive haemolysis test (Bushnell *et al.*, *Pacif. Sci.*, 1950, **4**, 167; George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42; Masilungan *et al.*, *Philipp. J. Sci.*, 1959, **88**, 245; Watt & Breyer-Brandwijk, 876).

Extracts of the fruit rind at a concentration of 10 g./litre are reported to show like other tannin-bearing plants, positive inhibition against the fungi *Piricularia oryzae* Cav. and *Colletotrichum falcatum* Went (*Physalospora tucumanensis* Speg.), the causal agents of rice blast and red rot of sugarcane, respectively. Pressed leaf juice showed a powerful inhibitory action upon tobacco mosaic virus infection (Janardhanan *et al.*, *Curr. Sci.*, 1963, **32**, 226; *Chem. Abstr.*, 1955, **49**, 8402).

The fresh pomegranate juice is used as an ingredient of cooling and refrigerant mixtures and of some medicines for dyspepsia. The rind is valued as an astringent in cases of diarrhoea and dysentery. The expressed juice of the leaves and the young fruit, and the decoction of the bark are used in dysentery. In Java, an ink is sometimes made from infusion of the leaves in native vinegar. The sweet types of pomegranate are said to be mildly laxative, while the less sweet types are believed to be good in inflammation of stomach and in heart pain. The powdered flower buds are used in bronchitis. The seeds are considered to be stomachic and the pulp cardiac and stomachic [Burkill, II, 1842; Katyal & Chadha, *Fertil. News*, 1962, **7**(4), 25; Hayes, 405; Kirt. & Basu, II, 1085].

The plant is sometimes grown as an attractive hedge. The wood is hard (wt., 897 kg./cu.m.) and can be used for small objects. The wood might be tried as a substitute for boxwood [Katyal, *Indian Fmg*, *N.S.*, 1955-56, **5**(12), 39; Hayes, 405; Burkill, II, 1843; Gamble, 377].

PUPALIA Juss. (*Amaranthaceae*)

A small genus of herbs or subshrubs distributed in tropical Asia and Africa. Three species occur in India.

P. lappacea Juss. syn. *P. atropurpurea* Moq.
Fl. Br. Ind., IV, 724; Fl. Delhi, Fig. 184.
GUJ.—*Gadarjhipato*; TAM.—*Adai-otti*.
DELHI—*Jhojhru, din ka tara, bhurat, chirchatta.*

An erect or straggling undershrub found in the hedges of fields, fruit orchards, dry scrub forests and waste places from Kashmir to Kumaun, at altitudes of 300-1,050 m., and in Punjab, Rajasthan, Gujarat, upper Gangetic plain, Bihar, West Bengal and Deccan. Leaves broadly ovate to lanceolate; flowers in axillary and terminal spikes; fruit an oblong membranous utricle, abruptly narrowed to the apex, enclosed in the perianth and surrounded by enlarged, stellately spreading, yellowish, hooked awns; seeds ellipsoid, compressed, black, shining.

FIG. 120—PUPALIA LAPPACEA—FLOWERING BRANCH

This weed is reported to cause loss in quality of wool gathered from sheep grazing in areas where it is common. The hooked fruits caught in the wool cannot be separated easily and such wool is classed as inferior (Mudaliar & Rao, 26).

In Africa, the fruit is applied locally for cuts, and forms an ingredient in enema preparations; mixed with palm oil, it is applied as a dressing for boils. It is given in the form of soup for cough and fever. The ashes of the burnt plant are mixed with water and taken for flatulence, and applied to leprosy sores after making them bleed. It is used as an ingredient in rat poison. In Senegal, the plant is employed as a bait to attract fish (Dalziel, 37-38; Kerharo & Adam, *J. Agric. trop.*, 1964, **11**, 571).

P. orbiculata Wight, a robust, sparsely pubescent plant found in Konkan and Carnatic coast, especially in sandy soil near the sea, is considered to be a sand-binder (Fl. Madras, 1173).

Purging Fistula — *see* **Cassia**

Purging Nut — *see* **Jatropha**

Purple Arrowroot — *see* **Canna**

Purple Flea-Bane — *see* **Vernonia**

Purslane, Common — *see* **Portulaca**

PUTRANJIVA Wall. (*Euphorbiaceae*)

A small genus of trees distributed in the Indo-Malaysian region. One species occurs in India.

P. roxburghii Wall.

D.E.P., VI(1), 372; I, 433; Fl. Br. Ind., V, 336; Kirt. & Basu, Pl. 864.

HINDI *Putranjiva, putijia, jiaputa, juti*; BENG.—*Putranjiva, jiaputa*; MAR.—*Jewanputr, putajan*; TEL.—*Kudrajuvi, kuduru, putrajivika*; TAM.—*Irukolli, karupalai*; KAN.—*Amani, putrajiva*; MAL.—*Pongalam*; ORIYA—*Poitundia.*

A mostly dioecious, evergreen tree with pendant branches, attaining a height of up to c. 18 m. and a girth of c. 2 m., found wild or cultivated almost in all parts of India, ascending up to an altitude of c. 750 m. Bark grey; leaves 5–10 cm. long, elliptic-oblong to ovate-lanceolate, dark green, shining; flowers small: male in dense rounded clusters, yellowish, female solitary or 2–3 together, green; drupe 15–18 mm. long, ellipsoid or globose, white-tomentose: stone pointed, rugose, very hard; seed normally 1, with copious albumen.

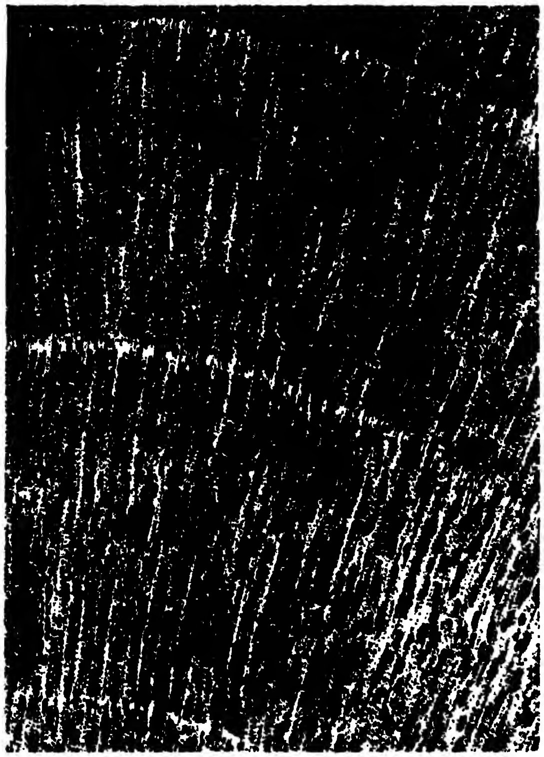
FIG. 121—PUTRANJIVA ROXBURGHII—FLOWERS AND FRUITS

The tree usually grows on alluvial soil along the rivers, or in swamps or evergreen forests and is sometimes gregarious: it is occasionally met with in rather stunted form in drier situations. Natural reproduction takes place through seeds during the rainy season and is quite abundant. Dissemination of seeds takes place through deer and bats which like the fruit. Artificial reproduction may be done through transplantation of one- or two-year old, nursery-raised seedlings. Transplantation is best carried out in rainy season. Young plants stand moderate shade and are sensitive to drought and frost. The tree is often planted in gardens, for hedges, and on roadsides, chiefly for shade. Several insect pests have been recorded on twigs, leaves and fruit [Troup, III, 828–30; Benthall, 387–88; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 86].

The wood is greyish white, shining, close-grained, hard, strong, heavy (wt., 586–785 kg./cu.m.) and durable. It is used for house building, agricultural implements, tool handles and turnery. Leaves and stones are given in decoction for cold and fever; they are also used in rheumatism. In Bihar, crushed leaves are reported to be applied to swollen throats of cattle. Leaves are also lopped for fodder. Stones of the fruit are strung into rosaries and necklaces (Gamble, 604; Duthie, III, 100; Kirt. & Basu, III, 2237; Talbot, II, 457; Caius, *J. Bombay nat. Hist. Soc.*, 1938–39, **40**, 307; Bressers, 21).

The seeds yield a fatty oil, used for burning. On extraction with petroleum ether, the seed kernels gave about 42 per cent of the oil having a pale yellow colour, a strong mustard odour and the following characteristics: sp. gr.$^{30°}$, 0.9075; $n^{30°}$, 1.4795; sap. val., 190.1; iod. val., 87.1; acid val., 7.2; R.M. val., 0.66; acet. val., 8.9; Hehner val., 94.0; and unsapon. matter, 0.95%. The fatty acids in the oil are: oleic, 47.4; linoleic, 15.3; palmitic, 7.1; stearic, 12.1; and arachidic, 2.1%. The oil contains small amounts of a mustard oil (Gambhir & Dutt, *Indian Soap J.*, 1945–46, **11**, 169; Krishna & Puntambekar, *J. Indian chem. Soc.*, 1931, **8**, 301).

The seed kernels on steam distillation yield 0.5 per cent of a sharp-smelling essential oil of the mustard



F.R.I., Dehra Dun. Photo : Ramesh Rao

FIG. 122—PUTRANJIVA ROXBURGHII—TRANSVERSE SECTION OF WOOD (×10)

oil type. The oil contains *iso*propyl and 2-butyl *iso*thiocyanates as the main constituents, and 2-methylbutyl *iso*thiocyanate as a minor component ; the *iso*thiocyanates are produced on enzymic hydrolysis of glucosidic progenitors present in the kernels, viz. glucoputranjivin, glucocochlearin and glucojiaputin, respectively. An additional glucoside, glucocleomin, has been identified in the seed kernels ; on enzymic hydrolysis it affords a non-volatile mustard oil, cleomin ($C_6H_{11}NSO$, 5-ethyl-5-methyl-2-oxazolidine thione). A glucosidic pattern similar to that in the seeds is reported in the shoots and roots (Puntambekar, *Proc. Indian Acad. Sci.*, 1950, **32A,** 114 ; Kjaer & Friis, *Acta chem. scand.*, 1962, **16,** 936 ; *Chem. Abstr.*, 1963, **58,** 1,342).

The fruit pulp contains a large proportion of mannitol, and small quantities of a saponin glucoside and an unidentified alkaloid ; the alkaloid is also present in a small quantity in the stones of the fruit (Krishna & Puntambekar, loc. cit.).

Puya Hemp — *see* **Maoutia**

PYCNANTHEMUM Mich. (*Labiatae ; Lamiaceae*)

Bailey, 1947, III, 2863.

A genus of aromatic herbs distributed in North America. These mint-like plants are easy to cultivate on any good soil. One species has been introduced into the Indian gardens.

P. virginianum Durand & Jackson syn. *P. lanceolatum* Pursh (VIRGINIA MOUNTAIN MINT) is grown in gardens for its beautiful masses of white or purplish flowers, which are borne in profusion during the summer months. It is an important honey-bee plant in America. The flowers are used as a flavouring. The herb is said to possess stimulant, antispasmodic, and diaphoretic properties. Dried herb yields 2.2 per cent of an essential oil. Carvacrol, geraniol, pulegone, menthol and menthone have been reported in the oil. The oil may be used in tooth powders or pastes, and for the preparation of menthol (Singh, *Bull. Indian Coun. agric. Res.*, No. 76, 1956, 28 ; Uphof, 301 ; Hocking, 184 ; Guenther, III, 691-93).

PYCNOCYCLA Lindl. (*Umbelliferae*)

Fl. Br. Ind., II, 694.

A small genus of perennial herbs distributed from North-East Africa to India. One species occurs in India.

P. glauca Lindl. (MUNDARI—*Gara etetel*) is a much-branched herb, with a woody rootstock, rush-like stems, 20–60 cm. high, and pinnately dissected leaves, bearing white or purplish flowers in heads, found in Punjab, Bihar and Madhya Pradesh. The roots of the plant are used in Bihar as a remedy for dysentery (Bressers, 71).

Pygeum — *see* **Prunus**

Pyrethrum — *see* **Chrysanthemum**

Pyrites — *see* **Sulphur and Pyrites**

PYROLA Linn. (*Ericaceae ; Pyrolaceae*)

A small genus of perennial herbs distributed in the temperate regions of northern hemisphere and also in the temperate zone of tropical America. One species occurs in India.

P. rotundifolia Linn.

Fl. Br. Ind., III, 475 ; Blatter, II, 14, Pl. 37, Fig. 1.

A glabrous perennial herb with rhizomes found in the north-western and eastern Himalayas, at altitudes of 2,700–3,000 m., and in Khasi and Jaintia hills up to 1,500 m. Leaves round, broadly egg-shaped or elliptic, 2.5–5.0 cm. diam., leathery ; flowers white or

pink, in long scapigerous racemes; fruit a capsule, crowned by the persistent style; seeds minute.

This species is circumboreal and includes a number of varieties, the western Himalayan forms referred to var. *rotundifolia* and the eastern Himalayan and Khasi hill forms to var. *asarifolia* DC. The plant contains two glucosides, namely arbutin (2.05% in fresh leaves) and ericolin which account for its diuretic and antiseptic properties. Methyl arbutin, ursone, gallic acid, and a quinone chimaphiline ($C_{21}H_{21}O_4$, m.p. 113°) are also present. The plant is also considered astringent and antilithic, and is used for healing wounds. The leaves are used as tea. A decoction of the plant is prescribed against profuse menses, bloody stools, haemorrhages, and ulcers in the urinary passages (Wood, *J. Arnold Arbor.*, 1961, **42,** 62; Decaux, *Acta Phytother., Amst.*, 1961, **8,** 81; *Chem. Abstr.*, 1939, **33,** 1876; Uphof, 301; Steinmetz, II, 349; Hocking, 185).

Pyrolusite — *see* **Manganese Ores**

Pyrope — *see* **Garnet**

Pyrophyllite — *see* **Steatite and Talc**

Pyrrhotite — *see* **Nickel Ores**

Pyrrosia — *see* **Pleopeltis**

PYRULARIA Michx. (*Santalaceae*)

A small genus of shrubs and trees distributed in North America, India and China. One species occurs in India.

P. edulis A.DC.

D.E.P., VI(1), 373; Fl. Br. Ind., V, 230.

NEPAL—*Amphi*; LEPCHA—*Safihy*, *toktor-kung*; BHUTAN—*Pyabdechu*; KHASI—*Dieng-so-klong*; MIKIR—*Thing-beng*.

A small to medium-sized, deciduous, often thorny tree found in the eastern Himalayas and the hills of Assam, ascending up to an altitude of c. 1,800 m. Leaves up to 17 cm. long, elliptic- or ovate-oblong, coriaceous; flowers mostly monoecious, small; drupe pyriform or globose, 2.5–5.0 cm. long, crowned with the perianth lobes; seeds globose.

The fruit is edible and tastes like guava. Seeds are found to contain a fatty oil. The wood is white, close-grained, moderately hard and heavy (wt., 753–801 kg./cu.m.). It is used in North Bengal to make implements for churning butter. The sap is reported to be used as rennet for curdling milk (Cowan & Cowan, 114; Wehmer, I, 260; Gamble, 585).

PYRUS Linn. (*Rosaceae*)

A small genus of deciduous trees and large shrubs distributed in the temperate regions of the Old World. Some of the species formerly included under this genus are now transferred to *Malus* and *Sorbus* (q.v.). Three species are recorded in India, of which two are cultivated for their fruits.

The genus *Pyrus* is known in wild state only in Eurasia and the main centres of speciation are situated in eastern Asia, in the Himalayas, Middle Asia, Caucasus and Asia Minor. At present, Caucasus is considered to be the main centre of speciation. Based on their original geographic distribution, the more important species are classified into two groups, Occidental (European and West Asian) and Oriental (East and Northern Asian) (Zhukovsky, *Euphytica*, 1965, **14,** 177; Zielinski, 186).

P. communis Linn. COMMON OR EUROPEAN PEAR

KASHMIR, PUNJAB, UTTAR PRADESH—*Bagugosha*.

D.E.P., VI(1), 374; C.P., 910; Fl. Br. Ind., II, 374; Bailey, 1947, III, 2805–06, 2867–68.

A tree with a broad pyramidal crown, distributed in the temperate regions of Europe and West Asia. Leaves orbicular-ovate to elliptic, crenate-serrate; flowers white, in few flowered corymbs; fruits variable, turbinate or subglobose, calyx lobes persistent, the flesh with gritty concretions.

This species includes a large number of varieties of which two are important, viz. var. *communis* [syn. *P. communis* var. *pyraster* Linn.; *P. pyraster* (Linn.) Borkh.] and var. *sativa* DC. (syn. *P. domestica* Medik.; *P. sativa* Lam. et DC.). Var. *communis* which includes the wild pears is usually a thorny tree, with flowers 2.0–2.5 cm. across and fruits 1.5–2.0 cm. across, and is distributed in middle and southern Europe, Asia Minor, Caucasus and northern Iran. Var. *sativa* is a thornless tree with larger leaves and flowers and large, juicy fruits, and includes almost all the cultivated types of pears, some of which may, however, be hybrids. There are also ornamental forms such as cut-leaved, lobe-leaved and variegated (Rehder, 403; Bailey, 1947, III, 2867–68).

Europe (with the exclusion of the Mediterranean region) is considered to be the centre of origin and development of this highly polymorphous species. Many of the cultivated types of *P. communis* probably owe their origin to the initial population of natural and artificial hybrids between var. *communis* (the Wild Pear) and *P. nivalis* Jacq. (Snow or Cider Pear), a native of eastern Europe.

Amongst temperate fruits, the pear stands next to the apple in total world production (about one-third that of apples), diversity of types (over 5,000 named types) and popularity as a dessert fruit. Germany, Italy, France and Switzerland in Europe, and the U.S.A. and Japan together produce annually more than half of the world production of pears which is nearly five million tonnes. In India, the pear is cultivated on a much smaller scale than the apple. The area under pear in India is about 1,400 ha., the chief areas of cultivation being Punjab, Kashmir, Himachal Pradesh and Madras, while Delhi, Uttar Pradesh, Assam and Bengal have smaller areas under this fruit (*Fruits*, Commonwealth Econ. Comm., 1964, 33; Sham Singh *et al.*, 331; *Agric. Marketing India, Bull. Marketing Some Important Stone, Pome and Small Fruits and Pine-Apples in India, Marketing Ser.*, No. 62, 1950, 5).

Pear breeding on a systematic scale was practised particularly in Belgium and France as well as England during the 18th and 19th centuries and resulted in many well known superior types, like *Bartlett* and *Winter Nelis*. The classification of pear types is said to be more difficult than that of apples or other similar fruits. The fruits are very variable in shape and one of the main causes for this is the extent of fertilization of the ten ovules in a normal flower, the shape of the fruit perfected without the development of a single seed being very much different from that with all the ovules developed into seeds. Some systems of classification based partly on a natural and partly on arbitrary characters or fully on arbitrary characters of the fruit have been devised, but none has gained any wide acceptance (Magness, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 615; Chandler, 1957, 317; Zhukovsky, *Euphytica*, 1965, **14**, 177; Zielinski, 188, 192; Chittenden, IV, 1507).

Bagugosha (*Citron des Carmes*) is said to be the chief type grown in Punjab and Kashmir; *Williams' Bon Chritien* commonly known as *Bartlett*, is another important type grown in these regions. Other types recommended for cultivation are: *Conference, Clapp's Favourite, Doyenne du Comice, Dr Jules Guyot, Easter Beurre, Emille d' Heyst, Marie Louise d' Uccle, Thompsons* and *Winter Nelis* (Sham Singh *et al.*, 332; Hayes, 434).

The basic chromosome number of the pear is 2n=34 as in the apple. There are a large number of types which are triploids: a few tetraploids have also been reported. Genetical investigations into the mode of inheritance of some fruit and leaf characters have also been made. The common pear has been crossed with other species like *P. pyrifolia* (Burm. f.) Nakai (the Japanese Pear) and *P. ussuriensis* Maxim. Though no progeny of high quality has occurred in the F_1 generation, as the low quality of these species seems dominant over the high quality of common pears, some of the back crosses with the

FIG. 123—PYRUS COMMUNIS AND P. PYRIFOLIA—FRUITS

common pear have been rated high. Hybrids of the pear with the apple have also recently been raised successfully making use of hormone treatment (Magness, loc. cit.; Crane & Lawrence, 153; Crane & Marks, *Nature, Lond.*, 1952, **170,** 1017; Brock, *Heredity*, 1954, **8,** 421; Williams, *Rep. Innes hort. Instn*, 1958, 7–13).

CULTIVATION

Climate and Soil—Pear is less hardy and grows in general in a somewhat warmer climate than the apples. It is said to require c. 900–1,000 hours below 7° to adequately break its rest period. In India it is grown at elevations of 1,200–1,800 m. in Punjab, Himachal Pradesh, Kashmir, Uttar Pradesh and Assam and in the Nilgiris at elevations of 1,600–2,000 m. It is best grown on a deep and warm soil retentive of moisture, though in actual practice it is generally grown on poor and marginal soils. It is said to be comparatively less affected by waterlogging during the rainy season (Shoemaker & Teskey, 135–36; Thapar, 95; Naik, 341; Jawanda, *Punjab hort. J.*, 1961, **1,** 150).

Propagation—The pear is propagated by budding or grafting on some kind of rootstock grown first in the seedbed and then in the nursery. The rootstocks used in this country in the northern growing regions are generally *P. pashia* (*Kaenth* or *Shiara*) or the seedlings of commercial pear types. In the Nilgiris, the country pear (*P. pyrifolia*) is preferred for stock as the grafts give good orchard performance, though use of *P. pashia* is said to have the possibilities. *Sorbus khasiana* Rehder and *Malus baccata* are said to have long been used successfully in Assam for rootstock. In Europe and America, the pear is grafted or budded on seedlings of commercial pear types like *Bartlett* and *Winter Nelis*, but the plants so raised are susceptible to the attack of fireblight disease under American conditions. Though other alternative rootstocks have been tried, no satisfactory rootstock has yet been obtained. Quince (*Cydonia oblonga*) stocks have been used for dwarfing pears, though some of the pear types are not compatible with quince and require double working using an intermediate pear type compatible with quince [Thapar, 95: Naik, 342; Hayes, 434; Chandler, 1957, 328–30; Gourley & Howlett, 492–93; Shoemaker & Teskey, 130–32; Randhawa, *Indian J. Hort.*, 1950, **7**(2), 10; Sham Singh *et al.*, 333].

Outside India, *P. nivalis* Jacq., *P. betulaefolia* Bunge, *P. calleryana* Decne., *P. ussuriensis* Maxim. and *Crataegus* and *Sorbus* spp. have been used as rootstock for the pear, with varying success (Chandler, 1957, 328; Zielinski, 187–88; Gourley & Howlett, 509–10).

Cultural Practices—The methods of cultivation are in general like those described for apple (cf. *Malus*). Planting is done in autumn or winter in the northern cultivating areas and in January in the Nilgiris, giving a spacing of 6–7 m. or in the case of plants budded on quince stock, only 3.5–4.5 m. The trees are kept in vigorous condition so as to bear a good crop, but excessive growth in late summer is likely to favour blight infection. A cover crop which competes for food and water and thus retards this late growth of the plants is recommended in such cases. As the pear is a slow grower, intercropping with vegetables or fruits like cape gooseberry, strawberry or tree tomato is recommended in the Nilgiri hills (Sham Singh *et al.*, 333; Naik, 343).

With some exceptions like *Bartlett*, most pear types are commercially self-incompatible, the degree of incompatibility being related possibly to climatic conditions. Diploid types have viable pollen and, except in a few combinations, can successfully pollinate one another and provision must be made to grow such types in the orchard. Honey-bees are the chief agents of cross pollination (Sham Singh *et al.*, 331; Mukherjee & Shah, *Himachal Hort.*, 1961–62, **2 & 3,** 149; Chandler, 1957, 320–22; Shoemaker & Teskey, 145–47).

Pears are pruned and trained to form pyramids, bushes, espaliers and cordons. Pruning of branches and thinning of the fruits are recommended for obtaining good sized fruits and also to avoid biennial bearing tendency (Sham Singh *et al.*, 333–34; Chandler, 1957, 332; Shoemaker & Teskey, 147–51).

Diseases and Pests—The pear is said to suffer from comparatively few diseases or pests. Bark canker, caused by *Nectria* sp., is said to be serious in orchards in the Amritsar (Punjab) region. The canker appears on bud scars, wounds, etc. The greatest loss is sustained on trees up to 12–15 years of age. Remedial measures include burning all dead wood and prunings which are sources of infection, cleaning out of cankers and application of Bordeaux paste and paint, as well as spray. White rot of root and root collar caused by *Ganoderma* sp., are also destructive of trees up to 10–15 years of age. Prompt removal of infected roots or removal of severely infected trees is necessary. Treatment of the cut ends of infected roots, the trunk and collar region and the surround-

ing soil with suitable preparations is also to be followed (Chohan, *Punjab hort. J.*, 1961, **1,** 68).

Scab caused by *Venturia pirina* Aderh., has also been reported. It closely resembles the apple scab (cf. *Malus*), but is distinct from it. The general symptoms are similar but twig infections are said to be far more extensive. Spraying lime-sulphur mixture twice before and once after blossoming is said to control the infection (Paracer *et al.*, *Punjab hort. J.*, 1963, **3,** 30; Butler & Jones, 749–52).

A few other diseases like stem black caused by *Coniothecium chomatosporum* Corda, pink disease caused by *Corticium salmonicolor* Berk. & Br., and brown rot caused by *Sclerotinia fructigena* Aderh. & Ruhl., are common to the apple and pear and their control is similar to those of apple (cf. *Malus*) [*Plant Prot. Bull., New Delhi*, 1959, **11**(1–4), 56].

The San Jose scale, *Quadraspidiotus perniciosus* Comst., is a major pest in some areas on the pear as well as some other pome and stone fruits. The life history of this pest and control measures have been dealt with under *Malus*. Biological control of this pest by the introduction of suitable parasites and predators has recently been tried with some measure of success [Jolly, *Himachal Hort.*, 1961–62, **2 & 3,** 163; Chhotey Singh, ibid., 1961–62, **2 & 3,** 169; *Indian Hort.*, 1962–63, **7**(3), 6].

A number of beetles which defoliate the plant and damage the fruits are reported to infest the pear in Himachal Pradesh, Punjab and Uttar Pradesh. They are controlled by spraying with DDT or lead arsenate. In the Nilgiris a number of pests of the pear have been recorded and the use of BHC or Parathion spray is said to have given satisfactory control [*Plant Prot. Bull., New Delhi*, 1959, **11**(1–4), 20; Sharma & Surendra Kumar, *Himachal Hort.*, 1965, **6**(2–3), 5; Abraham & Padmanabhan, *Indian J. Hort.*, 1965, **22,** 214].

Harvesting and Yield—The trees come to bear in about seven years after planting and their profitable bearing life is said to be about 60–70 years. Harvesting of fruits in the northern cultivating areas starts in June and goes up to November in the case of late types, while in the southern cultivating areas it extends from May to September. Pears should, in general, be picked when fully mature but still hard and green. When they reach optimum maturity for picking they can usually be separated from the spur by a slight twisting pull. Early types are picked a little early and will be sufficiently ripe within the time taken in transporting to the consuming centres. Late types are harvested at a slightly later stage of maturity and have to be stored to develop their characteristic flavour. The yield per tree in the northern areas is said to be 75–120 kg., while in Coonoor it is only about half this figure.

Storage—The fruit is more easily perishable than apple. The various types differ as to length of time they can be stored successfully, the safe storage period varying from 2 to 7 months at c. −1°. Rust rot during storage can be controlled by wrapping the pears in copper-impregnated paper. The best ripening temperature for all types after storage is about 18° (Thapar, 97; Naik, 344; *Mem. Dep. Agric. Madras*, No. 36, 1954, 400; Sham Singh *et al.*, 334; Shoemaker & Teskey, 151, 154–55; Chandler, 1957, 326–27; Kirpal Singh, *Punjab hort. J.*, 1961, **1,** 142; von Loesecke, 1942, 450; Cruess, 178).

Small quantities of fresh pears are exported annually from this country mainly to East Pakistan while much larger quantities are imported, West Pakistan being the chief source (Table 1).

Utilization and Chemical Composition

Pears are consumed in India primarily as fresh fruit. In Europe, a good portion of the crop is crushed to produce juice for beverage and wine industries, while in U.S.A. large quantities are canned and some are dried. Pears are a good source of pectin and contain also appreciable amounts of sugars and thiamine. They are reported to help in maintaining a desirable acid-base balance in the human body. Pears have been recommended to patients suffering from diabetes because of the low sucrose content (Schery, 468; Tressler & Joslyn, 821; *Chem. Abstr.*, 1932, **26,** 1357; 1956, **50,** 8934).

Chemical composition of some important types of pears grown in India is given in Table 2. A sample

TABLE 1—EXPORT AND IMPORT OF FRESH PEARS*
(Qty in kg. and Val. in Rs.)

	Export		Import	
	Qty	Val.	Qty	Val.
1962–63	258,268	61,517	9,298,733	1,503,177
1963–64	188,630	69,002	6,360,408	875,631
1964–65	59,990	22,443	1,202,445	356,736
1965–66	8,218	3,291	2,323,684	473,635
1966–67	..	..	..	..
1967–68	200	100	114,441	40,748

* Includes figures for quince also from 1965–66 onwards.

of pears from Kashmir contained: acidity (as malic), 0.24; reducing sugars, 8.2; total sugars (as invert), 10.8; and tannins, 0.04%. The trace elements in pears include boron, copper (119.5 μg./100 g.), molybdenum (3.4 μg./100 g.), zinc, cobalt (44.9 μg./100 g.), arsenic, fluorine (0.03 mg./100 g., dry matter basis), and iodine (up to 2.0 μg./100 g.). Pear flesh contains 0.012 per cent and skin 0.03 per cent of phosphatides. During ripening of pears, the changes in composition consist mainly in a steady increase in sugar content and a small increase in acidity (Andrabi & Magar, *Indian J. appl. Chem.*, 1959, **22**, 231; *Chem. Abstr.*, 1941, **35**, 2561; Winton & Winton, II, 594; Hulme, *Advanc. Fd Res.*, 1958, **8**, 297; Garber, *Qualit. Plant. Mat. Veg.*, 1962–63, **9**, 33; Iodine Content of Foods, 100; Jacobs, II, 1535; Thorpe, IX, 256).

Reducing sugars, of which fructose is the major component, constitute over 80 per cent of the total sugars present in pears. Analysis of 26 types of ripe pears gave the following values for sugars (g./l. of the juice): fructose, 65–112; glucose, 5–35; and sucrose, 1–24. Pears also contain maltose, galactose, xylose and probably arabinose. Two keto-oligosaccharides, sorbitol and a cyclitol (probably meso-inositol), have been detected. Other carbohydrates in pears include starch and cellulose. During ripening, the starch of the fruit is converted into sugars. The pear starch granules are almost round (diam., 4–6 μ) and similar to those of apple starch in shape and amylose content (32.9%) (Hulme, loc. cit.; Andrabi & Magar, loc. cit.; Ash & Reynolds, *Aust. J. Chem.*, 1955, **8**, 276; *Chem. Abstr.*, 1938, **32**, 621; 1964, **61**, 13562).

TABLE 2—COMPOSITION OF EDIBLE PORTION OF IMPORTANT TYPES OF PEARS GROWN IN INDIA*

	Pears, *Bagugosha*	Pears, *Kashmiri Nakh*	Pears, Country	Pears, *Kieffer*
	(1)	(2)	(3)	(4)
Moisture, g./100 g.	86.5	83.6	86.0	86.3
Protein, g./100 g.	0.4	0.2	0.2	0.2
Fat, g./100 g.	0.1	0.3	0.1	0.2
Minerals, g./100 g.	0.3	0.4	0.3	0.2
Fibre, g./100 g.	2.1	0.6	1.0	1.4
Other carbohydrates, g./100 g.	10.6	14.9	12.4	11.7
Calcium, mg./100 g.	20	20	6	10
Phosphorus, mg./100 g.	20	20	10	10
Iron, mg./100 g.	1.5	1.0	1.0	0.4
Vitamin A, I.U./100 g.	0	0	14	9
Thiamine, mg./100 g.	..	..	0.02	0.03
Riboflavin, mg./100 g.	..	..	0.03	0.02
Nicotinic acid, mg./100 g.	0.2	0	0.2	0
Vitamin C, mg./100 g.	1	3	0	7

* Nutritive Value of Indian Foods, 72, 107–08, 136.

NOTE—Nos. 1 and 2 are types of *P. communis*; No. 3 is a type of *P. pyrifolia*; No. 4 is a hybrid.

The pectic constituents in pears depend on the type, the stage of ripening and the storage conditions. During ripening, protopectin is largely hydrolysed into soluble pectin and this conversion is the principal factor concerned with the softening of pears. The soluble pectin content of *Bartlett* pears was found to be 0.07 per cent at the time of picking (unripe stage) and 0.7–0.8 per cent in the ripe fruit. When the pears are first cold-stored and then ripened, there is a fall in both protopectin and soluble pectin. In another study, the soluble pectin was 0.1–0.2 per cent in picked unripe pears and 0.6–0.8 per cent in the fruits ripened by ethylene treatment; the total pectic substances amounted to about 0.9 per cent in most pickings. Pear pectin yields 82.6 per cent of anhydro-uronic acid, and the sugars identified include arabinose, galactose, rhamnose and xylose (Kertesz, 312–13; Hulme, loc. cit.; Date & Hansen, *Curr. Sci.*, 1953, **22**, 145; *Proc. Indian Acad. Sci.*, 1954, **39B**, 171; McCready & Gee, *J. agric. Fd Chem.*, 1960, **8**, 510).

Pears have a very low nitrogen content. Protein nitrogen constitutes only about 8 per cent of the total nitrogen. Lysine, phenylalanine and leucine are the most abundant amino acids in the protein of pears, especially during maturation. The free amino acids identified in pears are asparagine, serine, glycine, aspartic and glutamic acids, α- and β-alanines, γ-amino butyric acid, cystine, ornithine, glutamine, proline, hydroxyproline, methyl hydroxyproline, tyrosine and all the essential amino acids except tryptophan (Hulme, loc. cit.; *Chem. Abstr.*, 1946, **40**, 3561; Andrabi & Magar, loc. cit.).

The vitamin values of pears range as follows: vitamin A, <50 I.U.; thiamine, 2–50 μg.; riboflavin, 7–30 μg.; and ascorbic acid, 1–11 mg./100 g. Pears also contain biotin, pantothenic acid, folic acid and vitamin B_{12}. Besides other B-vitamins, inositol (240 mg./l.) and vitamin B_6 (0.13 mg./l.) have been recorded in pear juice. The concentration of ascorbic acid and biotin is found to be much greater in the peel than in the pulp of pears. On the tree, the ascorbic acid content of the pears is highest during the early stages of development when the seeds are soft and still undeveloped, after which it falls rapidly

(Thorpe, IX, 256 ; Hulme, loc. cit. ; Andrabi & Magar, loc. cit. ; *Chem. Abstr.*, 1957, **51**, 632).

Malic and citric acids are the principal organic acids present in pears. Table pears contain more of malic acid while in some juice pears, citric acid accounts for up to 45 per cent of total acids. Other acids detected in pears are quinic (10–20% of the total), α-ketoglutaric, succinic, lactic, glycolic, shikimic, glyceric and mucic acids. Citramalic acid has been identified in the peels but not in the pulp (Hulme, loc. cit. ; Anet & Reynolds, *Nature, Lond.*, 1954, **174,** 930 ; *Chem. Abstr.*, 1962, **57,** 17152 ; Andrabi & Magar, loc. cit.).

A low melting light green wax can be separated from the peels. It contains saturated (C_{16}–C_{21}) and unsaturated (mainly oleic, some linoleic and linolenic) acids, ternary mixtures of primary alcohols (C_{20}–C_{30} predominantly lignoceryl and ceryl), nonacosane, and ursolic acid (Warth, 289).

The typical aroma of *Bartlett* pears has been attributed mainly to the presence of esters. An unsaturated acid, *trans*-2, *cis*-4-decadienoic acid, has been identified. Several esters of this acid, notably the ethyl ester, have been isolated from the flavour concentrate and have been shown to have remarkably pear-like odours, which make up the final flavour of the fruit. *n*-Hexyl acetate has been shown to contribute to the flavour of pears. The presence of 45 components in *Bartlett* pear essence has been reported (Nursten & Williams, *Chem. & Ind.*, 1967, 486).

The tannin content (total catechol derivatives) is 0.1 per cent in dessert pears. It increases during the early stages of growth and later on decreases. The major components of tannin fraction are complex leucoanthocyanins composed of units similar to cyanidin. The polyphenols include gallic, ellagic, chlorogenic and *iso*chlorogenic acids. Anthocyanin and flavone pigments have also been reported in pears (Hulme, loc. cit. ; Kieser *et al.*, *Chem. & Ind.*, 1953, 1260).

The enzymes present in pears are amylase, catalase, peroxidase, xanthine oxidase, pectin polygalacturonase, protopectinase and pectase (pectin methyl esterase). A high pectin polygalacturonase activity has been demonstrated in ripe *Bartlett* pears. The pectase activity is high in pears during the early stages of development on the tree and comes down to a minimum at the time of picking ; during ripening, there is again an increase. Polyphenolase is considered to be responsible for the browning of pears when cut, chlorogenic acid being the chief substrate. A thermolabile inhibitor of pectinase was found in the juice of some types of pears (Hulme, loc. cit. ; Winton & Winton, II, 593 ; *Chem. Abstr.*, 1949, **43,** 7603 ; 1954, **48,** 8332).

Ripe pears contain appreciable amounts of acetaldehyde which is believed to be the causative agent in the production of scald and breakdown in the fruits. The extent of scald is stated to be directly related to the concentration of acetaldehyde in the tissue. The disagreeable taste and odour preceding and accompanying scald and breakdown are attributed to this compound (Jacobs, II, 1535).

Pear seeds contain (dry matter basis): crude protein, 33.4 ; fat, 24.8 ; lecithin, 1.2 ; sugars (as invert), 5.1 ; pentosans, 6.7 ; fibre, 10.9 ; and ash, 3.8%. Amygdalin is reported in minor amounts. The seeds yield a clear yellow fatty oil with a very mild odour and taste, and having the following characteristics: sp. gr.$^{20^\circ}_{20^\circ}$, 0.912 ; $n_D^{40^\circ}$, 1.465–1.468 ; acid val., 1–5 ; sap. val., 189–197 ; iod. val., 121–127 ; R.M. val., 0.3 ; Polenske val., 0.3 ; and unsapon. matter, 0.5–1.1%. The fatty acids are made up of about 10 per cent saturated and 90 per cent unsaturated acids. Pear seed oil is similar to apple seed oil and can be refined to a pale bland product suitable for culinary purposes (Winton & Winton, II, 590 ; Eckey, 461 ; Mensier, 456 ; Kester, *Yearb. Agric., U.S. Dep. Agric.*, 1950–51, 594).

PEAR PRODUCTS

Canned Pears — *Bartlett* pear is preferred for canning because of its uniform shape, white colour and relatively small number of grit cells. In India, the *Bartlett* pears of Kulu, after picking, are ripened at 24–27°. The fruits are peeled from the stem end to the blossom end, longitudinally cut into halves, and the core removed. They are then kept in salt solution (1–2%) to prevent browning, syrupped, sterilized and then promptly cooled in cans. Syrup-packed canned pears contain: water, 81.1 ; protein, 0.2 ; fat, 0.1 ; carbohydrates, 18.4 ; fibre, 0.8 ; and ash, 0.2%. The quality of the canned product depends greatly on the picking of the fruits at the proper maturity, and ripening at the proper temperature. The flesh of too immature fruits becomes yellow and stringy after canning, while that of over-mature fruits becomes highly soft around the core (Cruess, 178–81 ; Lal Singh *et al.*, *Indian J. agric. Sci.*, 1951, **21,** 137 ; Girdhari Lal *et al.*, 69–70 ; Watt & Merrill, *Agric. Handb., U.S. Dep. Agric.*, No. 8, 1950, 38).

Pear waste obtained during the peeling, coring and stemming operations in the canneries amounts to

30–35 per cent. The fresh waste contains: total solids, 14.8–16.3; protein, 0.5–0.6; crude fibre, 2.2; total sugars, 7.1–8.3; and ash, 0.3–0.4%. It can be used in the preparation of vinegar, brandy or denatured alcohol. Some pear waste is employed in making a syrup suitable for canning of pears, or for table use. It is also dried and processed to a useful stock feed, comparable in nutritive value to beet pulp mixed with beet molasses. Pear waste can be used as a soil conditioner and in composting (Cruess, 180, 764; *Chem. Abstr.*, 1948, **42**, 5131; Neubert *et al.*, *J. agric. Fd Chem.*, 1954, **2**, 30; Kefford, *Food Pres. Quart.*, 1964, **24**, 21).

Pear Juice—A clear juice of excellent flavour can be prepared from *Bartlett* pears, the process requiring treatment with a pectic enzyme. It is recommended for use in jellies and sherbets, and after acidification as a beverage. In California, the *Bartlett* is the principal type used for making pear nectar (Tressler & Joslyn, 821–22).

Dried Pear—Limited quantities of pears are preserved by sun-drying; cull pears from canneries are used more for this purpose than the whole pears. Fruits picked while still too green for eating are ripened for 8–10 days, cut, sulphured (for up to 72 hr.) and spread in the sun for a day or two. The process is completed by slow drying in the shade to obtain an attractive product. The product should be tender, pliable, translucent and of a light colour. Dried pears contain: protein, 4.4–5.1; carbohydrates, 63.2–64.4; and ash, 1.2–1.4%; calcium, 25–29; phosphorus, 29.2–39.2; iron, 0.25–0.64; and potassium, 543–741 mg.; carotene (as vitamin A), 20 I.U./100 g. For dehydration, pears are picked ripe, peeled, cut and sulphured for 15–20 min. and dried at 60–63° for 15–24 hr. The yield is 14–19 per cent and the product is superior to sun-dried pears for culinary purposes. Pears are also candied, and sweet-pickled [Cruess, 480, 569–70, 607; Girdhari Lal *et al.*, 246, 251–52; *Chem. Abstr.*, 1947, **41**, 7008; *Indian Fd Packer*, 1956, **10**(7), 11].

OTHER USES

Extracts of different parts of the plant have shown variable antibacterial action. Fresh pear juice exhibited good activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. An aqueous extract of the leaves was active against some strains of *Escherichia coli*. Chlorogenic acid is present in the vegetative parts of the tree. The leaves contain arbutin, *iso*quercitrin, sorbitol, ursolic acid, astragalin and tannin (0.8–2.9%). They dye mordanted wool to yellow and brown shades. The bark contains friedelin ($C_{30}H_{50}O$, m.p. 254–56°), epifriedelinol ($C_{30}H_{52}O$, m.p. 275–76°) and β-sitosterol. Phloridzin is present in the root bark (Watt & Breyer-Brandwijk, 894; *Chem. Abstr.*, 1954, **48**, 6079; 1959, **53**, 8310; 1962, **57**, 15511; 1938, **32**, 621; 1958, **52**, 20894; Hulme, loc. cit.; Perkin & Everest, 634; Kierstead, 88; Chakravarti *et al.*, *J. Indian chem. Soc.*, 1964, **41**, 859).

PEAR WOOD

Pear wood (wt., 705–833 kg./cu.m.) is reddish yellow or pink, soft, close and even-grained. Owing to its extraordinary smoothness and evenness of texture, it is said to be excellent for engraving and turning, and especially for mathematical and drawing instruments and rules (Gamble, 321; Howard, 448).

P. pashia Buch.-Ham. ex D. Don

D.E.P., VI(1), 376; Fl. Br. Ind., II, 374.

HINDI—*Mehal, mol.*

PUNJAB—*Kaenth, sheghel, batangi, tang, shiara*; ASSAM—*Soh-shur, soh-jhur, chalthei.*

A small or medium-sized deciduous tree distributed in the temperate Himalayas and in Assam at altitudes of 600–2,500 m. and also in a restricted area in the north-eastern part of Madhya Pradesh. Branches often spinescent; leaves 3-lobed, sharply serrate, glabrous or woolly beneath; flowers white; fruits globose, small, 2–4 cm. in diam., dark yellow-brown, scurfy, covered with raised white spots.

This tree is very common in open sunny slopes and is said to reproduce from root suckers with great freedom. It is a tree of moderate growth and can be grown from cuttings (Troup, II, 490).

This tree is favoured as a rootstock for the common pear (*P. communis*), and also the apple. There are two forms of this species, one bearing small fruits and the other larger ones. The tree is also top-worked with superior types of the common pear, particularly in the Kulu valley and Kumaun, where thousands of trees occur. Some of the improved types found suitable for top-working are: *Victoria, Beurre Hardy, Conference, Jargonelle, Nakh Kashmiri, Doyenne du Commice* and *Williames Bon Chritien* (*Bartlett*). The top-working is done in February before the sprouting of new buds. The trees so worked upon are fairly hardy and drought resistant and are said to start bearing fruits of good quality within 3–4 years of the operation [Thapar, 94; Chadha, *Indian J. Hort.*,

1957, **14,** 119; Srivastava, *Indian Hort.*, 1964–65, **9**(2), 9; Srivastava & Lal Singh, *Punjab hort. J.*, 1966, **6,** 177].

The fruits remain hard with a firm whitish astringent flesh until November or December, when the flesh begins to ripen, turns black and sweetish, and is edible. They may be gathered, dried and stored for use later, when they are ground and mixed with the flour of wheat, or of *mandua* or *ragi* (*Eleusine coracana*). Ripe fruits contain: total solids, 25.1%; protein, 1.8%; and ascorbic acid, 3.2 mg./100 g. As the fruits ripen, the starch is converted into sugars and at full maturity they contain 3.3 per cent of sugars [Troup, II, 490; Bhargava, *J. Bombay nat. Hist. Soc.*, 1959–60, **56,** 26; Tewari, *Punjab hort. J.*, 1965, **5**(1), 24].

The leaves and twigs are said to be lopped for fodder. The wood (wt., 753 kg./cu.m.) is used for walking sticks, combs, tobacco pipes, textile mill bobbins and as fuel. Bark contains friedelin (0.5%) and β-sitosterol. Leaves contain *n*-hentriacontane (1%), myricyl alcohol and β-sitosterol (Ishaq, *Pakist. J. For.*, 1957, **7,** 20; Gamble, 324; Chakravarti *et al.*, *J. Indian chem. Soc.*, 1964, **41,** 83).

P. pyrifolia (Burm. f.) Nakai var. **culta** (Makino) Nakai syn. *P. serotina* var. *culta* Rehd.; *P. sinensis* Hort. non Lindl., nec Poir. SAND PEAR, CHINESE OR JAPANESE PEAR, COUNTRY PEAR

PUNJAB, UTTAR PRADESH—*Nashpati*; MADRAS—*Berikai.*

Bailey, 1949, 514; Rehder, 404.

A small tree, 9–15 m. high; leaves ovate-oblong, 10–15 cm. × 7–10 cm., very dark green; flowers white, in an umbel; fruit *c.* 9 cm. across, mostly apple-shaped with a depression at stem end, the calyx lobes falling before maturity; flesh hard.

This species is a native of China and Japan from where it has been introduced into various countries including perhaps India. The *nashpati* grown in the plains and hills of Punjab and in the Khasi hills of Assam where it is said to be naturalized, and also the so called country pear often semiwild in the Nilgiris all belong to this species. There are said to be about 220 ha. under these country pears in the Nilgiris and nearly 400 ha. under sand pears in Punjab. *Nashpati* is probably self-fruitful and bears abundant crops when grown by itself (Bailey, 1947, III, 2505, 2869; Hayes, 434; Naik, 340; *Mem. Dep. Agric. Madras*, No. 36, 1954, 395; Kirpal Singh & Batra, *Punjab hort. J.*, 1961, **1,** 155; Sham Singh *et al.*, 331).

The Chinese sand pear, said to be blight-resistant, was introduced and widely disseminated over the eastern U.S.A. Very soon natural hybrids between this species and the types of European pear (*P. communis*) already under cultivation there began to appear. Some of them like *Kieffer, Leconte, Garber, Douglas* and *Pineapple* became popular when blight hazard was great, even though they were all inferior in quality as dessert fruits compared to the buttery European pear types. Of these hybrid types, *Kieffer* has been introduced into India and is successful in South India. *Leconte* and *Smith* have been tried in Delhi (Zielinski, 192; Gourley & Howlett, 509; Naik, 340; *Mem. Dep. Agric. Madras*, No. 36, 1954, 395; Mukerji & Rana, *Punjab hort. J.*, 1966, **6,** 149).

The country pear of the Nilgiris is said to be preferred as rootstock for other types of pear grown there (Naik, 340).

The fruits of *P. pyrifolia* are relatively inferior in quality because of their hard and gritty flesh and are mostly suitable for canning or culinary purposes, but the plant is so prolific that its cultivation is said to be profitable in spite of the low price the fruits command in the market. They stand storage and transport better than other pears (Sham Singh *et al.*, 332).

The fruits of country pear have a crisp texture. They are rich in sugars and possess a refreshing sweet taste. Table 2 gives the composition of country pears and other types. Mineral composition of a sample of country pear was: magnesium, 11 mg.; sodium, 0.6 mg.; potassium, 135 mg.; copper, 159 μg.; and sulphur, 16 mg./100 g. Phytin phosphorus accounts for 66 per cent of the total phosphorus, whereas iron is present entirely in an ionisable form. Country pears are a good source of pectin (9.25% as calcium pectate, dry basis); the value recorded by another set of observers was 3.1%. The pectin (methoxyl, 12.0 and galacturonic acid, 91.6%) yields good jellies. Trials at Fruit Products Research Laboratory, Kodur (Andhra Pradesh) have produced a good canned product from *Kieffer* pears (Balasubramanian *et al.*, *Indian J. med. Res.*, 1962, **50,** 779; Damodaran & Rangachari, *J. sci. industr. Res.*, 1945–46, **4,** 298; Savur & Srinivasan, ibid., 1946, **5B,** 41; Rangachari, *Proc. Indian Acad. Sci.*, 1951, **33A,** 100; *Mem. Dep. Agric. Madras*, No. 36, 1954, 401).

Pyrus spp. — *see* **Malus, Sorbus**

Q

Quail Grass — *see* **Celosia**

Quails — *see* **Birds**

Quamachil — *see* **Pithecellobium**

Quamoclit — *see* **Ipomoea**

QUARTZ AND SILICA

D.E.P., II, 167 ; VI(1), 378 ; C.P., 561.

Silica (dioxide of silicon, SiO_2) is one of the principal constituents of the earth's crust, forming about 60 per cent of it. It occurs both in crystalline and amorphous forms in various geological formations. The anhydrous crystalline forms are represented by quartz minerals, while the amorphous varieties (hydrous silica carrying varying amounts of combined water) include opal and diatomaceous earth. Quartz, next to felspars, is the most abundant and widely distributed mineral. It is found in a great variety of forms and colours. Several varieties of quartz and silica are valuable as semi-precious stones, while many varieties find application in electronics, optical, abrasive, glass, refractory and other industries (Mellor, VI, 137 ; Encyclopaedia Britannica, XVIII, 830 ; Ladoo & Myers, 419).

Quartz (sp. gr., 2.60-2.66 ; H., 7 ; n_D, 1.544–1.553) is a hard, brittle, transparent to opaque mineral, with vitreous to greasy lustre, conchoidal fracture, rarely exhibiting cleavage. It is insoluble in all acids except hydrofluoric acid. Quartz is colourless when pure, but is generally met with in tints of red, orange, yellow, green, violet and black, depending on the nature of inclusions. Many tints disappear on heating. One of the quartz minerals, the rock crystal, possesses piezo-electric properties.

Quartz occurs in two modifications, viz. α-quartz, which is the usual type found in vein quartz and gem crystals, and β-quartz, which forms the quartz of granite. α-Quartz is formed at temperatures $<575°$: above this temperature β-quartz is the stable form which changes to tridymite at 870° and to cristobalite at 1,470°. Quartz is enantiomorphous, and simple crystals are either right- or left-handed with respect to rotation of plane of polarization. Twinned crystals, usually penetration twins, are common (Ladoo & Myers, 420 ; Dana, 470–72 ; Webster, I, 158 ; Encyclopaedia Britannica, XVIII, 831).

The various forms of quartz may be classified under phenocrystalline, cryptocrystalline, massive, and granular or clastic varieties. Phenocrystalline varieties are found as primary crystals of vitreous lustre in old acid igneous rocks or as secondary infillings into geodes. Cryptocrystalline quartz is believed either to be a mixture of crystalline quartz with amorphous opal, or a network of crystalline quartz with large number of micropores. Massive varieties commonly occur in quartz veins and pegmatites, and vary from the coarse or fine granular crystalline kinds to those which are cryptocrystalline. Granular or clastic varieties comprise siliceous fragmental "quartzose" material like sand, sandstone, and quartzite (Dana, 471–72 ; Deer *et al.*, IV, 181, 209–10 ; Ladoo & Myers, 185, 561).

Opals are considered to be formed by the deposition of a series of extremely thin layers of hydrous cryptocrystalline or colloidal siliceous material. They vary from colourless to black in tint. In precious opals, a play of delicate colours is observed and the common varieties also show a pearly opalescence (Deer *et al.*, IV, 210 ; Webster, I, 184).

The commercial minerals of silica fall under two groups, viz. gem-quality varieties and non-gem varieties. The information on occurrence and colour of gem-quality minerals is summarized in Table 1. The gem minerals, with the exception of opal, are all crystalline in nature. The non-gem group includes: (*i*) cryptocrystalline forms, viz. burrstone, flint, and chert ; (*ii*) the granular or clastic materials such as sand and gravel, sandstone, and quartzite : and (*iii*) amorphous minerals like diatomaceous earth and tripoli.

Burrstone is a white, grey, or yellowish, hard chalcedonic porous abrasive material ; it occurs in large masses. Flint and chert are very compact cryptocrystalline forms, usually of organic origin, occurring as nodules.

Sand and gravel are unconsolidated aggregates of highly siliceous grains of varying sizes with fluctuating amounts of different impurities. The finer aggregates are known as sand and the coarser ones as gravel. Sands are used for various purposes and are known accordingly by their trade names such as Building Sand, Burnishing Sand, Filter Sand,

Furnace Sand, Glass Sand, and Moulding Sand. They will be dealt under the title Sands. Glass Sand has already been dealt with separately in Wlth India—Raw Materials, IV, 131.

Sandstones are sedimentary rocks consisting of sand grains cemented by silica, iron, lime, etc. to varying degrees of compaction. They are mainly used as building material and have been dealt with under Building Stones (Wlth India—Raw Materials, I, 235).

Quartzite is the characteristic product of metamorphism of sedimentary or igneous siliceous rocks and is found in massive or granular forms.

Diatomaceous earth is formed from the deposits of skeletons and shells of siliceous organisms like diatoms, and tripoli is produced by the alteration of chert or by the decomposition of limestone containing high proportion of silica. The former is found in beds and the latter is met with as layers in compact limestones (Ladoo & Myers, 185, 561).

Large quantities of quartz and silica are produced all over the world, but the electronic grade crystals are obtained mainly from Brazil. Gem-quality minerals of quartz are obtained from Brazil, U.S.A., U.S.S.R., South Africa, Ceylon, Egypt, Switzerland, Germany and France. Brazil, Mexico and Czechoslovakia are important producers of opal. India is an important source of semi-precious varieties like chalcedony, amethyst, rock crystal, and opal. Considerable amounts of lower-grade silica are also mined in the country for use in glass, ceramics and other industries (Mellor, VI, 137; Jahns in Gillson *et al.*, 409–11; Ladoo & Myers, 428–29; *Indian Miner. Yearb.*, 1964, 717).

Distribution

GEM MINERALS

Rock crystal occurs in abundance in most parts of the Indian Union. Good crystals (weighing up to c. 9 kg.) have been found at Tankara (22°40′:70°48′) in Gujarat and worked by the lapidaries of Cambay. They are also found in vein quartz in the Rengdang gorge (26°19′:93°39′) in Mikir hills and North Cachar, Assam. Pebbles of rock crystal, smoky quartz, citrine and cairngorm are collected as Vellum stones from the beds of streams traversing the Cuddalore sandstones and are worked at Thanjavur and Tiruchchirappalli into watch glasses, spectacle lenses and other ornamental and useful articles. Milky and smoky quartz occur in geodes of Rajmahal Traps in Santal Parganas. In Orissa, large semi-transparent crystals have been found near Tarabha

TABLE 1—COLOUR AND OCCURRENCE OF GEM MINERALS OF SILICA*

Mineral	Colour	Occurrence
Phenocrystalline		
Rock crystal	Colourless	Distinct crystals, primary; also secondary infillings in geodes
White or Milky quartz	White	Vein quartz, often gold-bearing
Brown quartz	Light brown to black	Debris of weathered granite, also gravel beds
Morion	Black	do.
Cairngorm	Reddish to yellowish brown	do.
Smoky quartz	Smoky brown	do.
Citrine	Light golden yellow to reddish yellow	Gravel beds
Amethyst	Faint mauve to glorious purple	In cavities
Rose quartz	Pink	In pegmatite dykes
Cat's eye quartz	Honey-yellow, brownish to grey-green	Gravel beds
Crocidolite	Yellow to golden brown with golden silky lustre	In veins
Aventurine	Green	Quartzites
Cryptocrystalline (*Chalcedony*)		
Agate	Differently coloured bands; also dendritic	In geodes and gravel beds
Onyx	Banded with black & white layers	do.
Sardonyx	Banded with red & white layers	do.
Chrysoprase	Lovely apple-green to dingy-greenish yellow	In serpentine; gravel beds
Prase	Dull green	Gravel beds
Plasma	Dark green with white or yellow spots	do.
Blood stone or Heliotrope	Plasma with bright red spots	do.
Carnelian	Flesh-red to deep red	do.
Sard	Yellowish & brownish red	do.
Jasper†	Yellow, brown, red, or green	do.
Amorphous (*hydrated*)		
Opal	Red, green, blue, through all the shades of spectrum	In veins, cracks & cavities

* Webster, I, 158–91; Weinstein, 93, 178; Dana, 472.
† Heterogenous mass of cryptocrystalline silica pigmented with colourful minerals.

(20°44′:84°10′) in Baudh-Phulbani; they have also been reported from Bijkomar (20°40′:83°31′), Baidipali, Gandrail (near Bolangir), Sagriaghat (20°20′:83°14′), Pandri (21°10′:84°06′), Koinsar (21°15′:84°07′), Bharimura, Jugomura, Bhoipali (21°26′:84°04′), Meghpal, and Satasama. Rock crystals have been obtained from near Bakarapat (13°39′:79°10′) in Chittoor, from Konjora (22°45′:84°46′) in Ranchi, from Aurangpur (28°28′:77°16′) near Delhi, and from Mujrakundi (23°18′:87°01′) and Balidumdumi in Bankura, West Bengal. In Rajasthan, rock crystals have been recovered from Daosa in Jaipur, Nawai (26°22′:75°59′) and Hathona in Tonk, and Bhanna Chowki in Kishangarh (Chatterjee, 184; Coggin Brown & Dey, 626).

Rose quartz occurs in veins at Kodur (18°16′:83°36′) and as loose crystals in gravels at Sadanandapuram (18°14′:83°37′) in Andhra Pradesh. It is found near Warangal (17°57′:79°41′) where it is used for the preparation of cheap ring stones and jewellery. Beautifully tinted rose quartz is found in the pegmatites of mica belt near Parasabad in Hazaribagh district of Bihar. It is also reported from Reda (23°55′:73°00′) in Sabarkantha, Gujarat; Khairi (21°32′:78°53′) and Dudhara hill (21°30′:78°57′) in Chhindwara, Madhya Pradesh; and Jariana in Dungarpur, Rajasthan. Rose quartz veins have been recorded near Rangia Tikra (21°51′: 84°17′), Ghichamura (21°46′:84°06′) and Burhia Kata (21°18′:84°08′) in Sambalpur, Orissa (Chatterjee, 184–87).

Amethystine quartz is found in the cavities and veins of some of the quartz reefs in Bundelkhand granites near Bagaud (22°20′:75°53′), and is cut into studs and buttons at Indore. Small amethysts occurring in Deccan Trap geodes are collected from the bed of Narmada river near Jabalpur and are used for jewellery and beads. Amethyst occurs near Andar (25°32′:78°06′) in Shivpuri; and near Chitai (26°07′:78°39′), Gangari (25°36′:78°28′) and Chandeva (25°42′:78°32′) in Datia. In Andhra Pradesh, beautiful amethyst is found at Bowenpally near Secunderabad: it occurs in granites near Hyderabad and also about 96 km. north of it at Bekonenpett. It is found at Koilkuntla (15°14′:78°19′) in Kurnool. Geodes of quartz lined with crystals of amethyst occur near Burhait (24°53′:87°40′) in Santal Parganas. Occurrence of amethyst has been reported from north of Kishangarh (26°36′:74°51′), Rondeil (27°14′:75°53′) and Samod (27°12′:75°48′) in Rajasthan; near Kangayam (11°00′:77°34′) in Coimbatore, Madras; at several localities in Sutlej river valley in Himachal Pradesh; in Zaskar in Jammu and Kashmir; and near Kollengode (10°37′:76°41′) in Kerala (Chatterjee, 168–69).

Cat's eye quartz is found on and near the base of Bowa Goree and Bowa Abbas hills near Ratanpur (21°43′:73°11′) in Gujarat; in the bed of Krishna river near Palnad in Andhra Pradesh, and near Cochin and Quilon in Kerala (Chatterjee, 184).

Aventurine quartz of green tint is obtained from Mysore. Rich bluish green material is found near Belvadi in Hassan district and a banded type nearby Sindagere. Aventurine occurs in blocks on a low ridge near Metra (15°19′:76°37′) in Bellary district. A coarse grained quartzite of delicate pale aquamarine-green colour banded with deep purple is found at Nellore in Andhra Pradesh. It also occurs in Coimbatore district of Madras (Webster, I, 172–73; Iyer & Thiagarajan, *Bull. geol. Surv. India, Ser. A*, No. 18, 1961, 64).

CHALCEDONY is the name given to the type material of cryptocrystalline silica including agate, carnelian, onyx, plasma, bloodstone, chrysoprase, jasper and others. Chalcedonic silica commonly occurs in India in the cavities of volcanic rocks of the Deccan, the Rajmahal, and the Panjal Traps. These minerals are generally collected as pebbles from the gravel beds of the rivers draining the areas.

Agate of good quality is found in Gujarat in Ranpur (22°21′:71°46′), Ratanpur (21°43′:73°11′) and its vicinity, Kapadvanj (23°02′:73°08′), and Khijaria near Tankara (22°40′:70°48′). The material from these sources is used by the lapidaries at Cambay. Agate occurs in Gohilwad area, Junagadh, eastern Kutch, and in river terraces in the neighbourhood of Veratia (22°23′:70°26′). In addition to Khijaria, moss agate is obtained near Latipur (22°37′:70°35′), Badanpur (22°47′:70°40′) and Khakhra (22°22′:70°30′). Agate derived from the Narmada valley at Bheraghat or the Marble rocks (23°07′:79°51′) is used by the lapidaries at Jabalpur. In Madhya Pradesh, it also occurs near Nimach and Bhopal, in the Johilla valley in Shahdol and in the Deccan Trap areas of Dhar. Agate used for the manufacture of beads, signet heads, paper weights, etc. is obtained from Aurangabad, Paithan (19°28′:75°23′) and Ballarpur (19°51′:79°20′) in Maharashtra.

Agate has been collected in Andhra Pradesh from the bed of the Godavari river in the areas around Rajahmundry, and near Pungadi (17°01′:81°39′), and in the alluvium of the Krishna river in Palnad. In Bihar, nodules of agate occur near Burhait

(24°53′ : 87°40′) and neighbouring localities. It is found in river beds, and near Bayana and Buneerah (24°26′ : 73°44′) in Rajasthan. In Mysore, agate is obtained near Yanagundi (16°48′ : 77°08′) in Gulbarga and around a few villages in Hassan. It is reported from the Robertsganj (24°41′ : 83°03′) tahsil of Mirzapur, Uttar Pradesh; Bamanghati (22°13′ : 86°10′) sub-division in Mayurbhanj, Orissa; and near Rudok and to the north of Pangong lake in Jammu and Kashmir (Ladoo & Myers, 420; Dana, 472; Chatterjee, 165; Wlth India—Raw Materials, I, 36).

Carnelian occurs along with other chalcedonies in the Rajpipla area of Gujarat; in the bed of the Godavari around Rajahmundry in Andhra Pradesh; in the Deccan Trap areas of Dhar in Madhya Pradesh; in the beds of Banas and other rivers in Rajasthan; and near Rudock and north of Pangong lake in Jammu and Kashmir. In Bihar, it is found near Chumpar Pahar near Dubrajpur (24°24′ : 87°27′) in druses in traps (Chatterjee, 165–68).

Onyx is abundant near Vijarkhi (22°25′ : 70°14′) and Khokhari (22°23′ : 70°28′), in bedded lavas in Halar, and occurs in the Rajpipla area of Gujarat. It is found in the alluvium of the Krishna in Palnad, Andhra Pradesh; and in the beds of Banas and other rivers of Rajasthan in association with agate and other chalcedonies (Chatterjee, 165–68, 183).

Plasma occurs in the Rajpipla area of Gujarat and in trappean rocks of Bhopal and Aurangabad with other minerals of chalcedonic silica (Chatterjee, 166).

Heliotrope (Blood stone) along with other chalcedonies, occurs in the Rajpipla area of Gujarat, and Johilla valley in Madhya Pradesh. In Maharashtra, it is found in trappean rocks of Aurangabad and Govilgarh hills in Amraoti; the river Muta-Mula in Poona is noted for the production of fine specimens of blood stone (Chatterjee, 166–68).

Chrysoprase is obtained in Rajpipla area of Gujarat from agate-bearing conglomerates along with other varieties of chalcedonic silica (Chatterjee, 166).

Jasper with brilliant red streaks or spots is found near Tankara (22°40′ : 70°48′) and is worked in the lapidaries of Cambay; it is also reported from Rajpipla area. Attractive specimens of both green and red varieties are found in Bihar in the iron ore series of South Singhbhum. Jasper is common in the Dharwar and Bijawar formations throughout the peninsula, and the pebbles derived from them are found in river beds. Near Timappaghar, in the Sandur taluk of Bellary, Mysore, there are 90 to 120 m. high cliffs of beautiful vivid red and purplish grey banded jasper-hematite which could be easily quarried. Extensive occurrence of jasper in association with quartzite is met with in Mirzapur, Uttar Pradesh, between Agori (24°33′ : 82°58′) and Titihidar (24°31′ : 82°44′). Jasper pebbles along with other chalcedonies are collected from the bed of the Godavari around Rajahmundry in Andhra Pradesh, and that of Banas in Rajasthan. They are also found in the trappean areas of Madhya Pradesh and Maharashtra (Chatterjee, 165–68, 182; Coggin Brown & Dey, 624).

Opal is of common occurrence in the manganese mines of the Srikakulam district, Andhra Pradesh. Good opals are found at Kodur (18°16′ : 83°36′) and Kotakarra (18°22′ : 83°33′), and also near the city of Hyderabad. Opal occurs in Rajmahal hills in Santal Parganas; masses up to 30 to 60 cm. in diameter have been observed near Sahibganj (25°14′ : 87°38′), Bihar. In Madhya Pradesh, amygdules of white opal exhibiting variegated colours and pearly lustre occur in the traps near Gau-Ghatto on the Newaj river, and also scattered near Sedrah, Banakbeh, and Karkori. In Maharashtra, very fine specimens of milk-white opal with a flame coloured iridescence have been obtained on the banks of Sina river between Andargaon (18°02′ : 75°38′) and Pauda (18°16′ : 75°31′) in Osmanabad. Opal has been reported from Govilgarh in Amraoti, and Kandri (21°25′ : 79°20′), Kodegaon (21°25′ : 79°01′) and Sitabaldi (21°09′ : 79°05′) in Nagpur. Flame opal also occurs in ferruginous gravels near Rajpipla in Gujarat. Wood opal and milky white opal, replacing tree stems, occur near Alundalippur and Malvay near Ariyalur (11°09′ : 79°05′) in Madras. Massive milk-white opal is found near Srinagar (26°26′ : 74°50′) in Ajmer, Rajasthan. In Orissa, opal is reported from Boirani (19°35′ : 84°49′) in Ganjam; and brown opal is found in small seams with serpentine at Rutland Island (11°25′ : 92°40′) in Andaman and Nicobar Islands (Chatterjee, 183–84).

NON-GEM MINERALS

Massive quartz commonly occurs in quartz veins and pegmatites. It is found in localities too numerous to be detailed. Large quantities are mined in the States of Andhra Pradesh, Bihar and Rajasthan. In Andhra Pradesh, considerable quantities of pure vein quartz are extracted from mica mines in Nellore district and large quantities of milky white material are available at number of places in Kurnool. Vein quartz is obtained from several localities in Hazaribagh and

Singhbhum districts of Bihar; and it may be had as a by-product of mica mining from pegmatites in Koderma and other localities. In Rajasthan, it is mined from deposits near Jaipur and Ajmer, and is available in several places in Pali. Good deposits of reef quartz occur at Lameta Ghat in Jabalpur, Madhya Pradesh. Quartz of special purity has been observed in veins in Sambalpur and Koraput in Orissa. Vein quartz is obtained in Tiruchchirappalli district of Madras State, and in Bangalore, Gulbarga and Shimoga districts of Mysore. It has been reported from Bankura and Purulia in West Bengal (Chatterjee, 417–22; Coggin Brown & Dey, 389; *Indian Miner. Yearb.*, 1964, 711).

Quartzite is common in Archaean, Dharwar and older Purana systems. It consists of granular interlocking mass of quartz crystals with irregular boundaries. Quartzite useful in refractories is found in Ganjam, Koraput and Sambalpur areas of Orissa, near Monghyr in Bihar, and also in Delhi area [Chatterjee & Majumdar, *Indian Ceram.*, 1955–56, **2**, 141; Minhas & Bhaskar Rao, *NML Tech. J.*, 1959, **1**(2), 32].

Quartzites suitable as building stone and road metal occur practically in all the States of the Indian Union. They are dealt with separately under Building Stones and Road Metal respectively (*see* Wlth India —Raw Materials, Vol. I and Vol. IX).

Flint and *Chert* occur as nodules and masses in limestones, and as pebbles in river gravels. In Andhra Pradesh, flint pebbles have been obtained from the bed of the Godavari river near Rajahmundry and from the river gravel 3.2 km. east of Verbadur Droog in Kurnool. They have been obtained from Burhait and along the streams in the neighbourhood of iron-ore hills in Kolhan and Dhalbhum in Bihar. Flint pebbles occur near Ratanpur (21°43′:73°11′) in Gujarat; in Pulko hill near river Ken in Chhatarpur, Madhya Pradesh; and on the left bank of Rihand river between Chakari (24°28′:83°01′) and Kheona (24°31′:83°01′) in Mirzapur, Uttar Pradesh. A band of flints, resembling those of the Chalk formations of Europe, occurs in clays and shales near Coorchy-colum and Senderai in the Tiruchchirappalli district of Madras. Beds of pure white chert occur in the iron-ore series, particularly to the north east of Jamda (22°10′:85°26′) in Bihar; pebbles from these deposits, suitable for use in grinding mills, are found strewn along the streams draining the area. Beds of impure chert are abundant north of Chandil (22°57′:86°04′) in Singhbhum (Dana, 473; Coggin Brown & Dey, 463; Chatterjee, 1).

Burrstone used as millstone, has not been reported to occur in India. The indigenous millstones are made from sandstones.

Diatomaceous earth of low grade is known to occur on Camorta and Trincutte islands of the Nicobar group. A commercially unimportant deposit occurs near Timmayyapalam (16°03′:79°40′) in Andhra Pradesh. Deposits of silt containing diatoms have been located near Nerrakal and Alleppey on banks off the Kerala coast and on the banks of Buckingham Canal bordering the Pulicat lake north of Madras. Tripoli or tripolite has not been found in India [Coggin Brown & Dey, 464; Chatterjee, 145; Sahni, *Rec. geol. Surv. India*, 1942, **76**(12), 19].

Mining and Treatment

Vein quartz and silica sand are mined by open-cast method. The tendency of quartz crystals to fracture readily and their unpredictable distribution make mining with explosives and heavy machinery uneconomical. The quartz obtained as by-product of mica mining mostly comes from underground mines. Quartz, mined along with other minerals, is broken into pieces and hand-sorted. Pebbles are individually picked from river gravels and sold to lapidaries or their agents. Agate pebbles after being cleaned by chipping, are left in the sun for a couple of months, and then heated to a certain temperature before dispatch. Heating removes any cloudiness and intensifies colours.

Silica sand is generally screened and washed to remove clayey matter before it is used in industry. Massive quartz is generally heated before crushing; heating helps in dry crushing the hard material [*Indian Miner. Yearb.*, 1964, 712; Waesche in Gillson *et al.*, 689; Desai, *Indian Min. & Engng J.*, 1967, **6**(1), 25].

Properties and Uses

GEM MINERALS

Rock crystal (Hindi—*Sphatik, suryakantamani, sitamani*) is almost pure quartz, crystallizing in colourless transparent crystals, in rhombohedral trapezohedral class of hexagonal system. It is the only colourless stone found in abundance; the size of the crystals varies from minute to gigantic ones weighing more than 450 kg. Rock crystal possesses neither planes nor a centre of symmetry, but only axes of symmetry. The crystal exhibits pyro-electric

properties and gets positively and negatively charged on alternate prism edges with change in temperature. When a rock crystal is subjected to mechanical pressure, piezo-electricity is produced. Controlled pressures and electric charges produce vibrations of great frequency, and these can be amplified. Very rapid oscillations of electric charges applied to the faces of a section of piezo-quartz cause very sharply-defined vibrations of supersonic frequency. In rock crystal, the atoms of silicon and oxygen are arranged in a spiral form, which gives to the material power of rotating polarized light. Rock crystal is transparent to ultra-violet rays (Weinstein, 179-80; Webster, I, 161; Deer *et al.*, IV, 184).

Rock crystal has been valued as a raw material for the fabrication of art objects. However, its modern application in electronics far exceeds all other uses in importance. High quality crystal weighing more than 50 g. is utilized for a variety of purposes. It is used in the preparation of precision, electronic, and frequency control components including oscillators and filters used both in radio and telephone services. It is used in the control of accurate clocks, underwater signalling, acoustic anti-submarine devices, range and direction finders and seismographs. The application of quartz crystal as a transducer in ultrasonic devices has increased despite strong competition from barium titanate and magnetostrictive devices. Quartz crystal is fabricated into delay lines for use in radar (Waesche in Gillson *et al.*, 687; Webster, I, 163; Parthasarathi *et al.*, *Def. Sci. J.*, 1959, **9**, 94).

Synthetic quartz crystal—Only the finest rock crystals are suitable for electronic uses; they must be free from cracks, flaws, irregular growths, and inclusions, and also from optical and electrical twinning. As the supply of natural rock crystals from Brazil dwindled and their demand increased, a process known as hydrothermal process, for the production of synthetic quartz crystals was developed in the Bell Telephone Laboratories, U.S.A. Clear, pure quartz chips and small crystals not meeting the dimensional requirement of electronic grade crystals are used as a source material. Synthetic quartz crystals can be produced in any quantity and size. By precise cutting of the seeds, the crystals may be grown in configurations that allow more efficient sawing and shaping operations.

The crystal faces of the synthetic product allow easier orientation of the stock for cutting into crystal units. Synthetic quartz crystals are free from the foreign material usually found in natural quartz, and can be produced without optical or electrical twinning. They are now being commercially produced in several countries of the world. In India, synthetic quartz crystals (wt., *c.* 7 g.) of about 2.5 cm. diameter have been developed at the Central Glass and Ceramic Research Institute, Calcutta, from polycrystalline aggregate of high purity quartz [Coggin Brown & Dey, 625; *Times Rev. Ind., N.S.*, 1961, **15**(175), 79; Waesche in Gillson *et al.*, 687; Bandyopadhyay & Saha, *Res. & Ind.*, 1966, **11**, 78; *Chem. Weekly*, 1965, **10**(20), 24].

Optical quartz is a clear rock crystal usually in pieces of 500 g. or more. It must be flawless, free from strain and optical twinning, but not necessarily from electrical twinning. Optical quartz is employed for the lens systems of microscopes using ultraviolet light to obtain great resolution, and in the lenses and prisms of the spectrographs. It is used for wedges in petrographic microscopes and components in quartz refractometers (Ladoo & Myers, 422; Webster, I, 163; Waesche in Gillson *et al.*, 687).

Since large crystals of optical quality are scarce, high grade fused-quartz free from all defects and impurities except electrical twinning is used for the fabrication of optical components. Clear fused-quartz is a water clear, colourless product made from carefully sorted discards of radio-grade rock crystals. It is used for optical systems, ultraviolet transmission tubes, cells, and lenses, high tension electrical insulators, torsion suspension in scientific instruments, and chemical laboratory ware. Vitreous silica, fused-silica or translucent fused-quartz, are translucent or opaque types made from silica sand. They have lower density, lower mechanical strength, and greater porosity than fused-quartz and are used for less critical purposes (Ladoo & Myers, 423; Waesche in Gillson *et al.*, 687).

Rock crystal takes a good polish; though limpid and pure it lacks "fire". Because of its abundant availability it is low priced. Cut into faceted stones and as beads it is worth little more than the cost of cutting. Rock crystals can be easily coloured. Large crystals are carved into large pieces of art. In India, rock crystal has been used for making urns, caskets, vases and pitchers since 4th century B.C. Rondells, the small flat beads used for separating coloured stones in necklaces, are usually made of rock crystal, and the halves of composite soude emerald are usually pieces of rock crystal, often selected for the natural flaws they contain. Rock crystal is ground and polished into crystal-gazing balls, which are also made

from glass. A rock crystal ball feels much colder, and shows double vision of a dot when looked through it except along its optical axis (Webster, I, 161; Weinstein, 179–82; Coggin Brown & Dey, 625).

White quartz or *milky quartz* is a product of inclusion of gases or liquids in minute cavities of rock crystal, displaying chromatic effect when viewed from certain angles. Sometimes the milkiness is only superficial. Much of the vein quartz is white quartz and is often gold-bearing. The material containing gold grains has been cut as plates or cabochons. Milky quartz resembles moonstone, and is sometimes used for pendants and necklets. It can find wide application in so-called fashion jewellery because its colour matches well with other stones (Weinstein, 182; Webster, I, 164).

Brown quartz contains the two-phase negative-crystal cavities in which the liquid phase is usually carbon dioxide as inclusion. It shows quite a distinct dichroism, one ray being brown and the other pinkish brown. Its colour is generally ascribed to a colloidal distribution of silicon atoms or the presence of organic carbonaceous matter in rock crystal.

Brown quartz varies in colour from light brown to almost black. Brown quartz with smoky tinge is called Smoky quartz. On heating the colour of brown quartz is usually lightened, the final hue depending on temperature and the duration of treatment. Very dark quartz is known as Morion and is not much valued as cut stone. Reddish brown or brownish yellow quartz is called Cairngorm or Scotch topaz (Webster, I, 165; Weinstein, 182).

Yellow quartz, also known as Citrine or False topaz, varies in colour from a light golden yellow to a reddish yellow; the colour is probably due to the presence of a trace of ferric oxide. It shows perceptible dichroism. Citrine is a cheap stone used in jewellery. Natural citrine being fairly scarce, the majority of stones in the market are produced by heat treatment of brown quartz and amethyst (Webster, I, 165; Weinstein, 184–85).

Amethyst (Hindi—*Nil mani*) is a prized quartz mineral showing a remarkable twinning, and ranges in colour from a faint mauve tint to a glorious purple. The origin of its colour has been variously attributed to manganese, potassium ferrocyanide, ferric cyanide, an organic substance, concentration of molecules of different minerals along the contact zones of twinned lamellae, iron in a colloidal state, or titanium. Much amethyst is parti-coloured, and sections cut at right angles to the vertical axis are often seen to have alternate triangular sectors, coloured a strong violet while other alternate sectors are almost colourless; thus in a cut stone, colour-breaks with an angle of about 60° or straight banding, are common.

Amethyst shows distinct dichroism, the twin colours being bluish violet and reddish violet; this dichroism is absent in brown heat-treated stones. Under the Chelsea colour filter, amethyst appears reddish in colour. Amethyst is popular in jewellery and good quantities of it are shaped into ring stones, seals, brooches, beads, pendants and necklets. Massive amethystine quartz usually with heavy flaws is used for carving. Imitation amethyst is prepared from a low refractive index glass with pronounced swirl marks, and from suitably coloured synthetic corundum (Webster, I, 166–71; Weinstein, 185–88).

Rose quartz is less common, varying in colour from almost white to pink. It is usually massive and cloudy with fissures. Its colour is considered to be due to either titanium oxide or manganese. It shows fairly strong dichroism in deeper hued material. Rose quartz has poor colour appeal, and its colour fades when heated or exposed to strong sunlight. It is mainly used for carving figurines, ash trays and small objects of art. Rose quartz is also artificially stained (Webster, I, 171; Weinstein, 189).

Cat's eye quartz (Hindi *Lahsuniya, vidalaksh mani*) is an opaque greenish or greenish brown stone in its natural form, and may closely resemble the chrysoberyl cat's eye when cut to show the cat's eye streak of light, the colour of the cut stone ranging from honey yellow, brownish to grey-green. Cat's eye quartz owes its chatoyancy to a multitude of fibres of a fine asbestos oriented parallel to the principal axis of host quartz. It is often stained dark blue or pink. It is used for making seals, handles of sticks and umbrellas, boxes, and popular jewellery (Webster, I, 172; Weinstein, 188).

Crocidolite quartz (Tiger's eye quartz) is a fibrous variety of quartz of a brownish yellow colour sometimes with a blue tinge. It is a silicified pseudomorph after crocidolite-asbestos, showing the cat's eye effect when properly cut. On heating, it changes colour finally yielding a red stone. It is sometimes dyed. Crocidolite material is used for making flat plates, beads, cabochons, and cameos. The surface of this subtranslucent to opaque, yellow to golden brown stone, with a golden silky lustre, shows a series of lustrous yellow bands alternating with brown banding which reverse in colours as the stone is turned (Weinstein, 189; Webster, I, 172).

Aventurine quartz is a massive, opaque, dark green stone having inclusions of platy crystals of green chrome mica or an iron mineral: it exhibits a shimmer. India supplies most of the green aventurine quartz of commerce, also known as Indian Jade. Chinese hold this stone in high esteem. In western countries, it is regarded as being of little value. Aventurine is used for carved ornaments and beads; however, large pieces of good quality are comparatively scarce. An imitation of the reddish brown aventurine, called Goldstone, is made in Italy by introducing flakes of copper in molten glass. It is fashioned into cheap jewellery and ornaments for tourist trade (Webster, I, 172; Weinstein, 190).

Agate (Hindi—*Gomed, akik*) is banded or dendritic variety of chalcedony with a waxy lustre. The bands, broad or fine, run parallel to each other, straight, wavy, or zigzag, and are generally concentric; the porosity of layers facilitates artificial colouring. Dendritic agates (Moss agate or Mocha stone) contain tree-like patterns of mineral inclusions usually manganese dioxide, iron oxide or chlorite. Indian moss agates are considered to be of fine quality. The colour in banded agate may vary from layer to layer yielding milk-white, yellowish, reddish, brownish, and sometimes bluish and greenish shades. Agate is carved in a variety of ornaments like necklaces, rings, amulets, ear-rings, brooches, wristlets and beads. It is also made into articles like fulcra for delicate balances, small pestles and mortars, ink stands, clock faces, knife handles, and calendars. Agate pebbles have been used as grinding stones in ball mills (Webster, I, 178; Weinstein, 192; Sahni, *Indian Miner.*, 1948, **2**, 251; Wlth India—Raw Materials, I, 36).

Onyx (Hindi—*Gomed, gomedak*) is agate usually with black and white as alternating colours. If the alternating bands are red and white the stone is known as Sardonyx. Onyx and sardonyx are carved into cameos, cups, and vases. The black onyx of jewellery is stained chalcedony (Webster, I, 177; Weinstein, 195).

Chrysoprase is the most prized of chalcedonies ranging in colour from lovely apple-green to dingy greenish yellow, the colour being due to the presence of nickel either as oxide or silicate. Chrysoprase is usually cut in cabochons, beads, seals and cameos. Chalcedony with a multitude of hair-like crystals of actinolite gives a dull green stone called Prase. With mass of chlorite as inclusion chalcedony produces Plasma, a dark green stone speckled with white or yellow spots. Plasma is translucent to opaque and is sometimes cut for jewellery. When jasper colours the spots of plasma bright red, the stone is called Blood stone (Heliotrope), the popular seal stone. Indian blood stone from Deccan Trap rocks is considered the best. Blood stone is carved and mounted in rings (Webster, I, 175–78; Weinstein, 198–99).

Carnelian is a translucent brownish red or flesh-red chalcedony. The colour may be due to the inclusion of hematite. It may have developed through the heating effects and ultra-violet radiations from sunlight and exposure to moisture over long periods of time. Most of the commercial carnelian is stained or heat-treated.

Carnelian is used for beads, cabochons, ring stones, brooches, pendants, and ear-rings. Carnelian carvings of China are considered to be of fine quality. The stone is cut in India into beads, cups and vases; it is generally untreated and pale in colour. When the inclusion in chalcedony is limonite, the stone shows yellowish and brownish red colour, and is known as Sard. Greeks and Romans used it for engraved intaglios and seals. Sard is not attractive and is seldom used in jewellery (Weinstein, 196–98; Webster, I, 177).

Jasper (sp. gr., 2.58–2.91; H., c. 7) is an opaque, cryptocrystalline, massive, compact quartz containing many impurities. Its colours, dark red, brown, yellow, green, or grey, are rather dull and emanate from the inclusion of ferric oxides, iron silicates and clay. It is used to imitate lapis lazuli, but due to the variable porosity the blue colour is not uniform. The inferior material produced is sold as Swiss Lapis. Jasper is usually used for larger decorative work; brecciated jasper takes a good polish and is used for ornaments. Basanite is a velvet-black flinty jasper with a fine grain, and is used by jewellers for testing precious metals (Weinstein, 198; Webster, I, 182; Dana, 473).

Opal (Hindi—*Dhudia pathar*) (sp. gr., 2.15; H., c. 6; n_D, 1.45) is hardened silica-gel with 6–10 per cent of water in precious varieties which are the most highly prized of silica gems. Its characteristic play of colours, ranging over all the shades of spectrum, makes opal a unique stone. Being relatively soft, opal is easily scratched and has a tendency to crack or break. It is damaged by acids, alkalies or even by hot water. However, handled and worn with care it lasts almost indefinitely and can be easily repolished.

Of the four types of opals employed in jewellery, black opal with splendid mass of red or green flashes against blackish background ranks in beauty and

value with precious gems. Fire opal is transparent to translucent with an orange to red body. White opal shows fine play of colours against a light white background, and the water opal brilliant flashes of hues in water-white stone. Hyalite is a colourless transparent variety of opal. Under ultraviolet light white opal exhibits luminescence varying from white to bluish, brownish or greenish, with often a persistent green phosphorescence ; black opals are generally inert.

Opals are cabochon cut and faceted for setting and used as centre stones of pendants and brooches. They may be used for cameos. Thin strips of good opal are reinforced by poor quality opal or onyx, resulting in an opal doublet, which is shaped as one stone. Opal triplets are also made and a number of opal pieces are cemented together and worked into beads (Weinstein, 93 ; Webster, I, 184).

NON-GEM MINERALS

Massive quartz, quartzite, sand, sandstone, flint, chert, and *diatomaceous earth* constitute the common non-gem minerals of silica. All of these, finely ground, are used for wood polishing and finishing and as a filler in wood, fertilizers, insecticides, rubber, and road asphalt surfacing mixtures. Ground to various specifications they are used as abrasive in sand-paper, scouring and polishing compositions for metals and stones, lithographer's sand, tooth powders and pastes, filtering media, and inert extenders for paints. Moderately pure sand, massive crystalline quartz, sandstone, quartzite, or chert are used in the manufacture of silicon, ferro-silicon, and silicon alloys. Massive quartz and quartzite are used as flux in smelting basic ores and as a lining for acid towers. Pure pulverized quartz sand, tripoli and diatomaceous earth are used for the manufacture of sodium silicate and other chemicals, and pure quartz sand for silicon carbide and ordinary glass. In ceramics very pure silica is used as an ingredient of bodies, glazes, and enamels. Quartzite finds use in refractory silica bricks, sand and tripoli in foundry, and diatomaceous earth in heat and sound insulation and abrasives. Rounded flint pebbles are used as grinding pebbles (Ladoo & Myers, 428).

PRODUCTION AND TRADE

No separate data are available for the production of various gem and non-gem varieties of silica. Table 2 gives the production of quartz and silica, which includes, besides massive quartz, the data for granular or clastic varieties. As stated earlier, sand will be dealt with separately. Table 3 gives the consumption pattern for quartz and silica including massive and granular or clastic varieties.

Gem varieties of silica have been produced in India since ancient times, and worked in the lapidaries of Cambay, Jaipur, Jabalpur, Banda, Thanjavur, and Tiruchchirappalli. Indian silica gems, particularly those of chalcedonic varieties (agate, carnelian, onyx, etc.), have been considered to be of very high quality and produced in large quantities. Rock crystal, amethyst, and other crystalline varieties, and opal have also been produced in substantial quantities. The chief centres of production of agate pebbles are situated in Cambay area of Gujarat. Table 4 gives the production of agate in Gujarat during recent years. The value of chalcedony pebbles produced in the

TABLE 2—PRODUCTION OF QUARTZ AND SILICA IN INDIA DURING 1963-67

(Qty in tonnes and Val. in thousand Rs.)

	1963*		1964*		1965†		1966†		1967†	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
Andhra Pradesh	16,588	69	18,759	88	48,350	199	65,001	204	31,782	201
Bihar	42,998	1,115	21,278	353	19,099	261	35,166	409	35,765	479
Gujarat	23,550	108	36,491	137	29,637	149	28,493	117	37,086	136
Kerala	11,146	30	4,943	10	7,388	18	6,131	15	4,935	12
Madhya Pradesh	54,135	322	46,124	240	84,228	568	32,925	297	25,983	293
Madras	3,768	19	1,739	8	2,063	10	1,019	6	6,030[b]	16[b]
Maharashtra	18,812	140	23,226	169	21,183	151	17,272	125	13,934	101
Mysore	33,655	372	40,118	527	30,070	461	40,145	545	40,917	413
Rajasthan	45,193	441	52,293	577	53,700	640	49,428	675	54,266	675
Others[a]	121	1	2,691	16	1,415	16	607	10	8,142	103
TOTAL	249,966	2,617	247,662	2,125	297,133	2,473	276,187	2,403	258,840	2,429

* *Indian Miner. Yearb.*, 1964, 715 ; † *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11 & 12), 1:27 ; 1967, **7**(11 & 12), 1:27.

[a] Delhi, Haryana, Himachal Pradesh, Orissa, Punjab and West Bengal.

[b] Including production of Chert.

country for ball mill purposes was Rs. 58,000 in 1964 (*Indian Miner. Yearb.*, 1964, 110, 826; Jahns in Gillson *et al.*, 409–11; Coggin Brown & Dey, 621; Wlth India—Industrial Products, pt VI, 183).

Exports and Imports—Quartz and silica sand are exported in appreciable quantities; Japan is the principal buyer. Small quantities of these minerals are imported, mainly from U.K., Netherlands, Sweden, U.S.A., and Germany. Table 5 gives the exports and imports of quartz and silica sand in recent years. It is estimated that nearly 2,750 kg. of quartz crystals are annually imported for use in electronic industries [*Indian Miner. Yearb.*, 1964, 720–21; *Chem. Weekly*, 1965, **10**(20), 24].

TABLE 3—CONSUMPTION OF QUARTZ AND SILICA SAND BY DIFFERENT INDUSTRIES DURING 1962–64*

(Qty in tonnes)

	1962	1963	1964
Glass	47,749	126,036	125,202
Refractory, and Iron & Steel	197,319	118,120	158,128
Ferro Silicon	18,294	21,752	25,316
Foundry	10,099	21,084	25,028
Ceramics	4,552	7,043	9,259
Cosmetics	..	1,338	1,507
Others	986	959	956
TOTAL	278,999	296,332	345,396

* *Indian Miner. Yearb.*, 1962, 473; 1963, 612; 1964, 180.

TABLE 4—PRODUCTION OF AGATE IN GUJARAT DURING 1963–67*

(Qty in tonnes)

1963	794
1964	254
1965	425
1966	485
1967	452

* Desai, *Indian Min. & Engng J.*, 1967, **6**(1), 27; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11 & 12), 1:14; 1967, **7**(11 & 12), 1:18.

TABLE 5—EXPORTS AND IMPORTS OF QUARTZ AND SILICA SAND DURING 1963–67*

(Qty in tonnes and Val. in thousand Rs.)

	Exports		Imports	
	Qty	Val.	Qty	Val.
1963	266	17	26	10
1964	306	23	61	31
1965	1,332	61	146	78
1966	2,272	145	230	145
1967	3,388	266	499	492

* *Indian Miner. Yearb.*, 1964, 720–21; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11 & 12), 1:44, 48; 1967, **7**(11 & 12), 1:46, 50.

TABLE 6—IMPORTS OF DIATOMACEOUS AND TRIPOLI EARTHS DURING 1963–67*

(Qty in tonnes and Val. in thousand Rs.)

	Diatomaceous earth		Tripoli earth	
	Qty	Val.	Qty	Val.
1963	1,152	937	234	131
1964	1,536	1,180	45	26
1965	362	270	101	66
1966	88	100	66	54
1967	118	150	92	83

* *Indian Miner. Yearb.*, 1963, 137–38; 1964, 158–60; *Mon. Bull. Miner. Statist. & Inform.*, 1966, **6**(11 & 12), 1:47–48; 1967, **7**(11 & 12), 1:49.

TABLE 7—PRICES OF QUARTZ AND SILICA SAND IN MARCH–APRIL DURING 1964–67*

(Price in Rs./tonne)

Material	1964	1965	1966	1967
Quartz				
Lumps, 99% SiO_2 (F.O.R. loading station)	12†	14	15–18	15–18
Powder, 150 mesh (Ex-factory)	..	150	150	150
Powder, 200 mesh (Ex-factory)	200	230	230	230
Silica sand (Bombay)				
50/80 mesh	..	50–65	55–65	55–65
Glass quality	55–100	75–85	75–85	75–85
Silicate quality	40–45	40	40	40
Foundry quality	30–40	30–45	30–45	30–45
Powder, 200 mesh	..	220	220	220
Powder, 10–250 mesh	..	140	140	140

Miner. Markets*, 1964, **3(2), 11; *Indian Min. & Engng J.*, 1965, **4**(2), 10; 1966, **5**(2), 10; 1967, **6**(2), 6.
† 98% SiO_2.

Indian silica gems and articles made out of them have been in the international trade since long. Semi-precious chalcedonic varieties, like agate, carnelian, and onyx have been exported to various countries. However, the trade data for silica gems are not separately recorded (Coggin Brown & Dey, 621).

Imports of diatomaceous and tripoli earths are given in Table 6. Important exporting countries have been the U.S.A., U.K., Germany, Belgium, Italy, Algeria and Kenya (*Statist. Summ. Miner. Ind.*, 1960–65, 126).

Prices—Table 7 gives the prices of various grades of quartz and silica sand. There have been no significant fluctuations in prices during 1964–67.

QUASSIA Linn. (*Simaroubaceae*)

A genus of trees or shrubs distributed in the pantropics. Two species are found in India of which one, *Q. amara*, has been introduced into India and grown in gardens.

Q. amara Linn. SURINAM QUASSIA

Fl. Malesiana, Ser. I, **6**(2), 199; Brown, 1941, II, Fig. 122.

An erect shrub, 2–3 m. high, indigenous to Brazil and Guiana, grown in gardens in India for its handsome foliage and showy flowers. Bark light coloured; leaves unequally pinnate with broadly winged rachis: leaflets obovate: flowers purple, in terminal racemes; drupes 1–5, purple black, 12–13 mm. long; seeds globular.

The plant is propagated by seeds, cuttings or layers. The flowers appear from July to September (Gopalaswamiengar, 285).

Q. amara furnishes the bitter quassia wood known as Surinam Quassia in commerce. Surinam quassia resembles Jamaica Quassia obtained from *Picrasma excelsa* (q.v.) in respect of its appearance, structure of wood, chemical constituents, medicinal and insecticidal properties and uses. The wood of *Q. amara* is heavier, harder and more deeply coloured, light and soft, fine-textured, easily worked, finishing smoothly; the billets are usually thinner. More recently, β-sitosterone and β-sitosterol were isolated from the wood (Holman, 133 34; Record & Hess, 512: U.S.D., 1955, 1152: *For. Abstr.*, 1964, **25**, 464).

FIG. 124—QUASSIA AMARA—FLOWERING BRANCH

The root bark contains the bitter principle quassin, a volatile oil, malic acid, gallic acid, calcium tartrate and potassium acetate (Wehmer, I, 643).

Q. indica Nooteboom syn. *Samadera indica* Gaertn.; *S. lucida* Wall.

D.E.P., VI(2), 451; Fl. Br. Ind., I, 519; Fl. Malesiana, Ser. I, **6**(2), 199, Fig. 3.

MAR.—*Lokhandi*; TAM.—*Nibam, niepa, karinjottei*; KAN. *Nipa, samadera*; MAL.—*Karinjotta*.

A small evergreen tree, 9.0–10.5 m. high, found in evergreen forests in west coast and along backwaters and sandy places in Kerala. Bark pale yellow in colour; leaves large, elliptic-lanceolate or elliptic-oblong: flowers pinkish yellow, in few or many-flowered umbels; fruits large, flat, pear-shaped, containing a large, brown, curved seed. The plant is used for hedges (Bourdillon, 66).

Q. indica is a native of Malagasy and is the source of the Niepa Bark of commerce. The bark yields taraxerone, stigmastanon, stigmasterol, 2,6-dimethoxybenzoquinone, samaderin-A ($C_{18}H_{18}O_6$, m.p. 255–58°), samaderin-B ($C_{19}H_{22}O_7$, m.p. 235–40°), samaderin-C ($C_{19}H_{24}O_7$, m.p. 265–68°), lupenone and a ketone (18α-oleanan 19α-ol-3-one). The bitter principle samaderin, isolated by earlier investigators, is found to be a mixture of at least 3 tricyclic terpenoid lactones, viz. samaderins A, B and C. The presence of ellagic acid, a glucosidic tannin substance, a yellow crystalline bitter substance, a red colouring matter and resin has also been reported. The bark is very bitter and is used as a febrifuge. In the Philippines, the juice from the pounded bark is considered a cure for skin diseases (*Chem. Abstr.*, 1963, **58**, 6888; Wintersteiner *et al.*, *J. org. Chem.*, 1965, **30**, 2847; Wehmer, I, 641; Kirt. & Basu, I, 508; Quisumbing, 475).

The wood is light (wt., 416 kg./cu.m.), soft and light yellow in colour, straight to slightly interlocked-grained, medium uniform in texture and diffuse porous. Wood is used for turnery articles, packing cases and planks for ceiling; it is suitable for light and cheap furniture and is useful as match wood [IS: 399–1952, 37; Chowdhury & Ghosh, *Indian For. Rec., N.S., Util.*, 1946, **4**(3), 19; Lewis, 84].

The wood and the root yield a bitter substance said to be identical with quassin. An infusion of wood is taken as a bitter tonic and used as a substitute for quassia. An infusion or decoction of wood and bark is also given as stomachic and emmenagogue (Wehmer, I, 641 ; Kirt. & Basu, I, 508 ; Burkill, II, 1946).

The seed kernels yield a golden yellow, bitter fatty oil (37%) which, freed of alcohol-soluble matter, showed the following characteristics: sp. gr.$^{20°}$, 0.9204 ; $n_D^{20°}$, 1.4713 ; acid val., 0.2 ; iod. val., 115 ; sap. val., 187 ; and unsapon. matter, 0.7%. The fatty acids of the oil are: palmitic, 9 ; oleic, 36 ; and linoleic, 48%. The alcohol-soluble fraction gave the glucosides samaderoside-A (m.p., 275–76° : $[\alpha]_D^{27}$, +97.4°) and samaderoside-B (m.p., 301–03° : $[\alpha]_D$, ±0°). Isolation of samaderin, inositol, and resin has been reported (Mitra & Garg, *Naturwissenschaften*, 1962, **49**, 327 ; Hilditch, 1956, 247 ; Wehmer, I, 643).

Seeds are used in Indonesia as an emetic, purgative and sometimes in bilious fevers. Seed oil is used as a local application in the treatment of rheumatism. Bruised leaves are applied externally in erysipelas. In the Solomon Islands, the macerated leaves mixed with coconut oil are used for cleansing hair. An infusion of the leaves is used for itch and to kill lice, fleas and white ants [Burkill, II, 1945–46 ; Kirt. & Basu, I, 508 ; Fl. Malesiana, Ser. I, **6**(2), 201].

Quassia, Jamaica — *see* **Picrasma**

Queensland Arrowroot — *see* **Canna**

Queensland Hemp — *see* **Sida**

Queensland Nut — *see* **Macadamia**

QUERCUS Linn. (*Fagaceae*)

A large genus of evergreen or deciduous trees or shrubs, mostly distributed in the temperate regions of the northern hemisphere and extending to subtropical and tropical America and Asia at high altitudes. About 23 species, most of them evergreen, are found in India in the Himalayan region.

The Indian Oaks are important both economically and sylviculturally. Many of them furnish timber and firewood. The barks of several species are rich in tannin ; their leaves and galls also contain tannin, but are not commercially exploited. Sylviculturally, some of them are of great importance as nurses to and companions of the important conifers with which they are frequently associated [Troup, III, 914 ; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145].

Q. acutissima Carruthers syn. *Q. serrata* Hook. f. (Fl. Br. Ind.) non Thunb.

D.E.P., VI(1), 386 ; Fl. Br. Ind., V, 601.

ASSAM— *Dingrittiang.*

A moderate-sized, deciduous tree, up to 25 m. high, with a straight bole, found in the Himalayas from Kumaun eastwards to Nepal, Bhutan and Assam and in Manipur and Khasi hills, at altitudes of 900–1,800 m. Bark dark grey ; leaves long-petioled, oblong-lanceolate, spinulose toothed ; male spikes long, tomentose ; female spikes short, flowers usually clustered ; acorns varying in size.

This is a fast-growing tree, suitable for plantations and for ornamental and shade purposes. It has been grown successfully in Coonoor, Nilgiris. It reaches fairly large dimensions (*c.* 2.0 m. in girth). It is a moderate light demander and is frost hardy. It coppices well up to moderate size (Troup, III, 939 ; Krishnamurthi, 225).

The wood is brown in colour, very hard (wt., 928 kg./cu.m.) and said to resemble that of *Q. griffithii* in structure ; the broad rays give a conspicuous silver grain in radial section. It is used in Assam for house building and for fuel (Gamble, 673 ; Fl. Assam, IV, 308).

Q. dilatata Lindl. ex Royle GREEN OAK, MORU OAK

D.E.P., VI(1), 380 ; C.P., 911 ; Fl. Br. Ind., V, 602 ; Troup, III, 923, Fig. 344–49.

PUNJAB—*Moru, chora, kali ring, barungi ;* KUMAUN – *Tilonj, kilonj.*

A very large tree, up to 25–40 m. in height, with a clean bole up to 20 m. in length and 6 m. in girth, found in the temperate Himalayas from Kashmir to Nepal, mainly at altitudes of 2,000–2,750 m. Bark turning dark grey to dark reddish brown with age and exfoliating in irregular woody scales ; leaves oblong or oblong-lanceolate ; male spikes crowded, up to *c.* 7.5 cm. long ; female spikes short, up to 4 cm. long ; acorns ovoid or oblong, brown, solitary.

Q. dilatata is a native of temperate areas where snowfall is heavy in winter. It avoids dry situations and favours moist, cool localities and northerly aspects. It is often found in dense, pure patches of varying extent, though it is also frequently found scattered in association with spruce (*Picea smithiana*) and other coniferous trees and broad-leaved trees like *Aesculus indica*, *Acer caesium*, etc. It attains its best

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FIG. 125—QUERCUS DILATATA

development on deep, rich, moist, but well-drained soil. Natural reproduction takes place by seeds which germinate soon after falling during the rainy season from August to October. Artificial propagation is possible either by sowing seeds directly as they ripen or by transplanting two-year old seedlings from the nursery or natural surroundings. Sowing and planting should be done on moist loamy soil in cool situations, with a spacing of 1.5 m. × 1.5 m. Its coppicing power is uncertain and young plants and coppice shoots are liable to browsing by goats. The growth is moderately fast. The seedlings are sensitive to drought, and subject to insect attack early in their life. The tree is susceptible to attack by fungi, causing various types of rots. Many larvae bore into the wood [Troup, III, 923, 926: Gamble, 673: Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 290; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 94].

The sapwood is grey and thin; heartwood light russet to pale greyish brown with darker streaks, heavy (sp. gr., *c.* 0.91; wt., 910–960 kg./cu.m.), very hard, strong and elastic, fairly straight-grained, medium fine but uneven-textured. The timber is durable, especially after treatment, and not very liable to insect and fungal attack. It is difficult to season. The timber is tough to saw and work (Pearson & Brown, II, 987).

The wood is used for building materials, agricultural implements, sleepers, axe handles, carrying poles, walking sticks and umbrella handles. It is very suitable for making spokes of heavy wheels and for making casks and barrels. It can be used as a substitute for imported oak from which kegs for maturing whisky are made. It is a good fuel wood (calorific value: sapwood—4,808 cal., 8,656 B.t.u.; heartwood—4,790 cal., 8,624 B.t.u.) and is used for making charcoal (Pearson & Brown, II, 988; *For. Res. India*, 1947–48, pt I, 56; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22).

The leaves and shoots are extensively lopped for fodder for sheep and goats. The galls on the leaves are said to be sweet and edible. An analysis of the leaves from Mukteswar gave (dry matter basis):

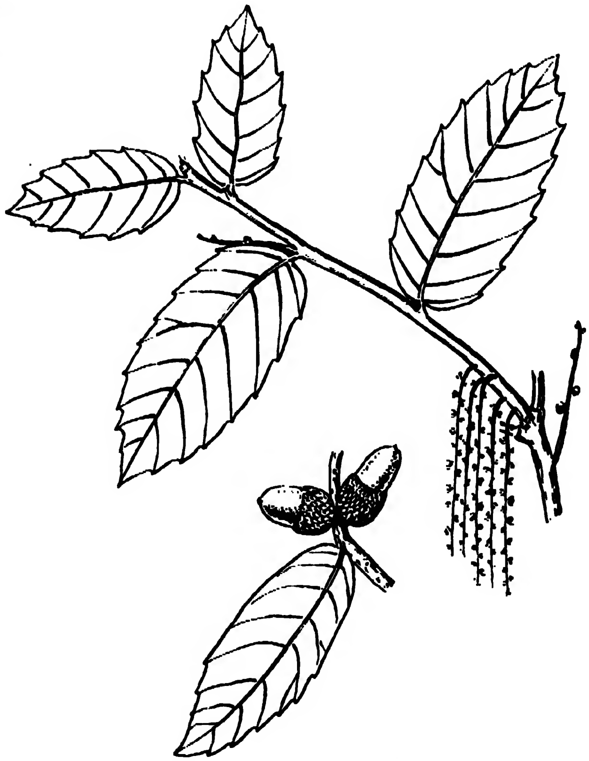
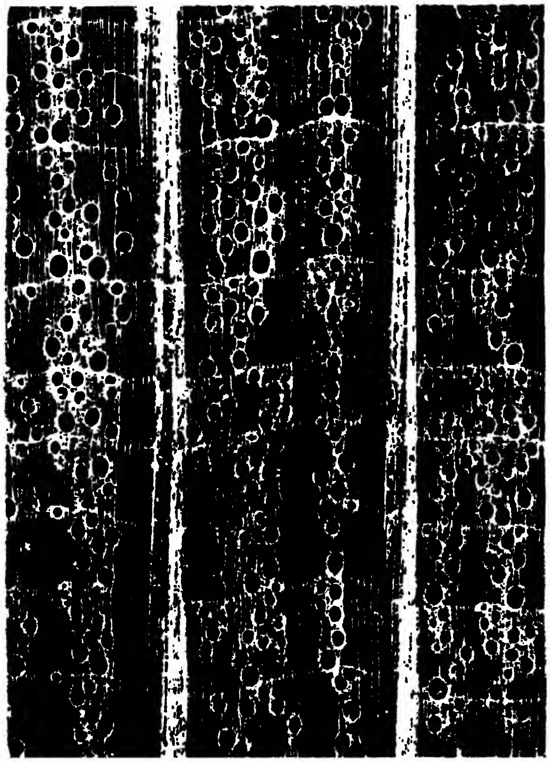


FIG. 126—QUERCUS DILATATA—FLOWERING AND FRUITING BRANCHES



F.R.I., Dehra Dun. Photo : Ramesh Rao

FIG. 127—QUERCUS DILATATA—TRANSVERSE SECTION OF WOOD (×10)

crude protein, 9.6 ; ether extr., 4.5 ; crude fibre, 29.1 ; N-free extr., 51.7 ; total ash, 5.1 ; calcium, 1.61 ; and phosphorus, 0.3%. The digestible nutrients of the leaves were as follows (dry matter basis): total nutrients, 43.2 ; protein, 4.2 ; carbohydrates, 38.5 ; and ether extr., 0.2% ; and nutritive ratio, 9.3. The acorns yield an orange coloured fatty oil with the following physico-chemical characteristics: sp. gr.$^{25°}$, 0.9084 ; $n^{30°}$, 1.4588 ; sap. val., 188.4 ; acid val., 22.2 ; acet. val., 21.1 ; iod. val. (Hanus), 90.3 ; Hehner val., 88.2 ; and unsapon. matter, 2.3% (Jain, *Indian For.*, 1956, **82,** 24 ; Lander, 280 ; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1964, 66–67, 118–19 ; Puntambekar & Krishna, *J. Indian chem. Soc.*, 1934, **11,** 721).

The leaves of *Q. dilatata* have been recommended as a source of tanning material ; they contain 9.8 per cent tannin and 8.3 per cent non-tannin. The bark contains 5.0 per cent tannin and 9.6 per cent non-tannin and is poorer in tannin content than the bark of *Q. incana* (Tej Singh *et al.*, *Indian For.*, 1958, **84,** 574 ; Sarin & Kapur, *Bull. reg. Res. Lab., Jammu*, 1963, **1,** 137).

Q. glauca Thunb. BLUE JAPANESE OAK

D.E.P., VI(1), 381 ; Fl. Br. Ind., V, 604 ; Troup, III, Fig. 363–65.

NEPAL—*Phalat* ; LEPCHA—*Siri* ; KUMAUN—*Pharonj, phaniant* ; PUNJAB—*Bran, banni, imbri, banku.*

A handsome evergreen tree, up to c. 20 m. in height, found in the outer Himalayas from Kashmir to Bhutan and also in the Khasi hills at altitudes of 600–2,000 m. Bark thin, grey or blackish, smooth ; leaves oblong- or ovate-lanceolate, serrate, glaucous beneath ; male spikes very slender and hairy, female flowers, 2–5 on short axillary peduncle ; acorns single or in pairs, ovoid, pointed.

Q. glauca is not gregarious except along the banks of streams. It thrives best on moist, rich soil and does not grow well in dry situations. It withstands a considerable amount of shade. It coppices freely. Under natural conditions, germination commences early in the rainy season. It can be raised artificially either by direct sowing or by transplanting from the nursery. Plantations are best made in moist ravines and similar places. A few species of beetles are said to bore into the felled wood [Troup, III, 117 ; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 96].

The wood (wt., 880–990 kg./cu.m.) is very hard, close-grained, grey or greyish brown with wavy concentric bands. It polishes well, but is liable to warp and crack. It is fairly durable, when not much exposed. It is said to be used in construction of sledge runners, bridges and houses, but is not so much esteemed as some other oaks. It is mainly used for fuel (Gamble, 677).

The leaves are used as cattle fodder. Analysis of the leaves gave (dry matter basis): crude protein, 9.6 ; ether extr., 4.1 ; crude fibre, 29.0 ; N-free extr., 49.6 ; total ash, 7.6 ; calcium, 1.87 ; and phosphorus, 0.23%. Digestibility trials of the leaves gave the following values (dry matter basis): total dig. nutrients, 39.8 ; dig. protein, 4.6 ; dig. carbohydrates, 33.8 ; and dig. ether extr., 0.6% ; nutritive ratio, 7.7 [Purohit, *Indian Fmg, N.S.*, 1961–62, **11**(12), 5 ; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1964, 66–67, 116–17].

The bark contains tannin up to 12 per cent. The wood yields D-mannitol [Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145 ; *Chem. Abstr.*, 1963, **59,** 5661].

Q. griffithii Hook. f. & Thoms.

D.E.P., VI(1), 381 ; Fl. Br. Ind., V, 602.

KHASI—*Dingim.*

A small to large-sized deciduous tree found in the eastern Himalayas in Sikkim and Bhutan and in Manipur, Khasi and Naga hills at altitudes of 1,100–2,400 m. Bark dark ash-grey, deeply furrowed and warty; leaves obovate-oblong, or oblanceolate, pubescent beneath; male spike fascicled; acorns almost sessile, 2–5 at the end of branchlets.

The tree is gregarious. It coppices freely. It is a moderate light demander and its rate of growth is fast. Natural reproduction is by seeds. It regenerates freely in gaps and open spaces. It is reproduced artificially by line sowings. It is affected by rust [*Cronartium quercum* (Berk.) Miyabe]. The tree is subject to the attack of defoliating larvae and the timber is attacked by some borers [Troup, III, 943; Gamble, 674; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 96].

The wood is said to resemble that of *Q. robur* (English Oak) in appearance and structure. It is brown, very hard and of good quality; it is used in house building and for agricultural implements and also as fuel. The wood and bark contain 5–10 per cent tannin [Troup, III, 943; Gamble, 675; Bor, 119; Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145].

Q. ilex Linn. HOLLY OR HOLM OAK

D.E.P., VI(1), 381; Fl. Br. Ind., V, 602; Troup, III, Fig. 360.

PUNJAB—*Bre-chur, irri.*

An evergreen shrub or tree, up to 12 m. in height, found in the inner arid tracts of the Himalayas from the Sutlej valley westwards and in Kashmir at altitudes of 900–2,600 m. Bark dark grey, broken into small scaly plates; leaves very variable in shape and size, elliptical or oblong, entire or with large spinescent teeth; male spikes in drooping clusters, female spikes short; nuts oblong conical, light brown, 1.5–2.5 cm. long.

It is a typically xerophytic species with a capacity for producing root suckers, especially when stimulated by digging out or splitting stumps of felled trees. The wood is subject to the attack of some borers [Troup, III, 912; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 96].

Heartwood (wt., 960–1,120 kg./cu.m.) is red or reddish brown, very hard and durable. The wood warps and twists, but when seasoned it works very well and takes a fine polish. It is used for agricultural implements, tool handles and joinery. It yields good fuel and charcoal. The leaves and branches are lopped for fodder and the spiny branches are used for fencing. The acorns ripen about October and are said to be the most edible of all acorns; they are eaten in Europe, and also fed to livestock (Gamble, 674; Burkill, II, 1853).

The dried acorns on solvent extraction yield 8.5–13.2 per cent of an edible oil with the following characteristics: $d^{25°}$, 0.9079; n^{23}, 1.4685; acid val., 0.5–7.0; and iod. val., 86–88. The fatty acid composition of the oil is as follows: palmitic, 10.5–13.4; stearic, 0.5–2.0; oleic, 40.0–72.8; linoleic, 13.1–38.2; and linolenic, up to 2%. The residual meal is useful as a feed and has the following average composition: moisture, 9.9; protein, 6.8; oil, 0.5; fibre, 0.9; N-free extr., 76.9 (sugars, 0.8; reducing sugars, 0.6; starch, 47.0; and tannin, 0.5); and ash 5.0%. The acorns have been tried as a source of industrial alcohol (*Chem. Abstr.*, 1965, **62**, 4532; Holland, *Kew Bull.*, 1925, 195).

Q. ilex is believed to be the principal source of Abruzzo or Italian Galls (tannin content, 41%), which have been widely used in the past for tanning and dyeing purposes. The bark is also used for tanning; it contains 7–13 per cent tannin. The leaves contain 2.1 per cent tannin and 1.8 per cent non-tannin (Howes, 1953, 260; Hoppe, 753; Streets, 662; Wehmer, I, 225).

Q. incana Roxb. BAN OAK, GREY OAK

D.E.P., VI(1), 382; C.P., 911; Fl. Br. Ind. V, 603; Troup, III, Fig. 339–43.

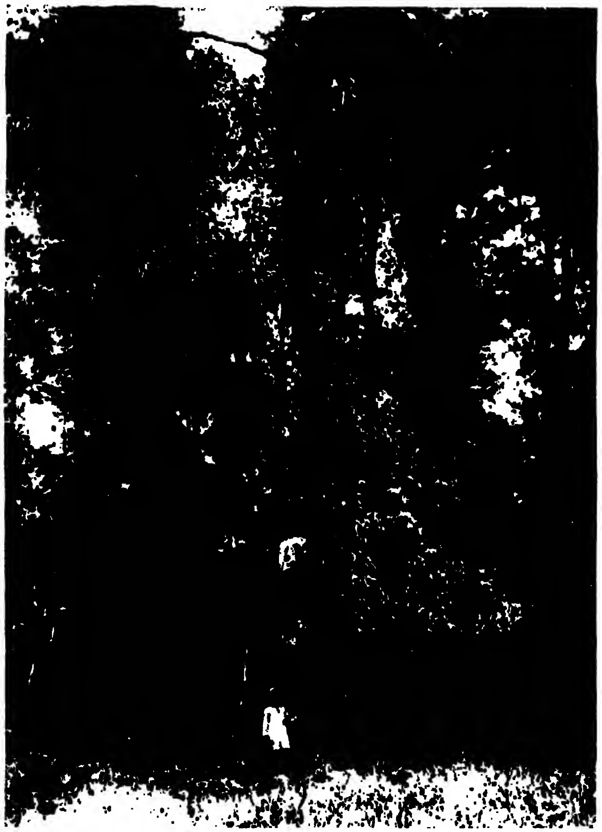
KASHMIR—*Sila supari, iri, shiddar*; PUNJAB—*Rin, rinj, vari, shindar*; KUMAUN—*Ban, bang*; JAUNSAR—*Inai, bani*; GARHWAL—*Phanat.*

A moderate-sized to large evergreen tree, up to 25 m. high and 3.0 m. girth, found in Kashmir and the western Himalayan regions up to Nepal at altitudes of 1,000–2,400 m., and occasionally descending into moist situations of Kangra and Kulu. Bark grey to greyish brown, silvery when young, peeling off in rounded flakes; leaves oblong- or ovate-lanceolate, with white or grey tomentum beneath; male spikes densely hairy and clustered, female flowers usually sessile; acorns single or in pairs; nut ovoid, brown with a grey pubescence near the apex.

Q. incana is gregarious and sometimes forms pure forests to a considerable extent. *Rhododendron arboreum, Cedrus deodora, Pinus wallichiana* and *P. roxburghii* are some of its commoner companions. It grows on a variety of geological formations, includ-

ing micaceous sandy soil. It attains its largest dimension on deep moist soil in cool northern aspects. It grows on the most arid slopes also, though it gets stunted and gnarled, while in moist valleys it is tall and straight. In its natural habitat, the climate is temperate, with shade temperature rarely exceeding 35° and the rainfall ranging from 100 to 230 cm. It does not extend into inner arid valleys (Troup, III, 915; Bor, 120).

Natural reproduction is from seeds. The seeds are produced in abundance. As the seeds are greedily eaten by birds and beasts even before they ripen, their survival is difficult, unless the ground below is well worked so that the falling acorns get covered with soil and are hidden. Artificial propagation is done by direct sowing or by transplanting seedlings raised in the nursery. The growth of the seedlings is somewhat slow and in the first few years, the plant withstands a fair amount of shade; thereafter it requires moderate to full sunshine for best development. It coppices well up to a girth of about one metre only. It suffers heavily by browsing and by frequent lopping for fodder. It is affected by *Loranthus* and *Viscum* spp. and by many rot-causing fungi. A very large number of beetles and other insect larvae that defoliate or bore into the wood and acorns have been recorded [Troup, III, 919–20; Chaturvedi, *Indian Frng, N.S.*, 1957–58, **7**(9), 12; Seth, *Bull., For. Dep., Uttar Pradesh*, No. 26, 1957; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 291; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 96].



F.R.I., *Dehra Dun*

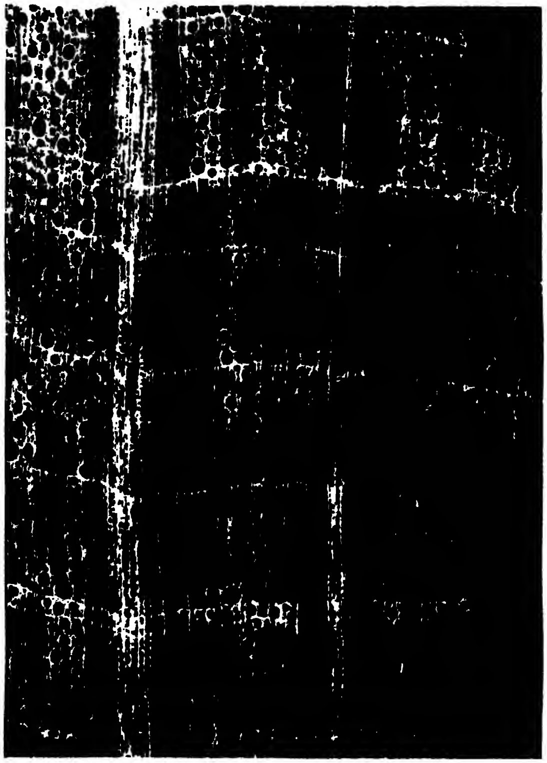
FIG. 128—QUERCUS INCANA

The wood is light russet to light greyish brown, with darker streaks along the grain, straight or somewhat wavy-grained, medium fine- but uneven-textured, very hard, moderately strong, and moderately heavy (sp. gr., *c.* 0.74; wt., *c.* 750 kg./cu.m.). It is liable to split and warp severely and is very difficult to season. It is moderately durable under cover, but liable to attack by large borers. It is not difficult to saw when dry and works to a smooth surface and takes a bright polish (Pearson & Brown, II, 990).

The wood is occasionally used for building and agricultural implements; it is suitable for tool handles. It is extensively used for fuel, both as firewood (calorific value: sapwood—4,633 cal., 8,339 B.t.u.; heartwood—4,566 cal., 8,221 B.t.u.) and as charcoal. The defibrated wood pulp can be used for the preparation of high grade hard-boards, with good strength and water-resistance (Pearson & Brown, II, 991; Gamble, 676; *Indian For.*, 1952, **78**, 369; 1948, **74**, 280; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22; Narayanamurti & Kultar Singh, *Curr. Sci.*, 1962, **31**, 97; *Chem. Abstr.*, 1954, **48**, 368).

The bark is extensively employed for tanning purposes; it contains 6–23 per cent of tannin. A sample of the bark gave 16 per cent tannin and 8 per cent of non-tannin. It was observed that the hide tanned with its extract (tannin, 85.4%) acquired a light biscuit colour superior to that imparted by wattle, and was not cracky. The stem bark contains friedelin, an unidentified triterpenoid, β-sitosterol, and a mixture of leucoanthocyanidins, one of which is leucopelargonidin. The wood contains 4–5 per cent of tannin [Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145; Santhanam & Barat, *Bull. cent. Leath. Res. Inst., Madras*, 1960–61, **1**, 20; Kalra *et al.*, *Curr. Sci.* 1966, **35**, 204].

The leaves are used as cattle fodder in the hills; they contain (dry matter basis): crude protein, 9.56;



F.R.I., Dehra Dun. Photo : Ramesh Rao

FIG. 129—QUERCUS INCANA—TRANSVERSE SECTION OF WOOD (×10)

ether extr., 4.8; fibre, 31.3; N-free extr., 48.4; total ash, 5.2; calcium, 0.99; and phosphorus, 0.15%. The digestible nutrients of the leaves are as follows: total nutrients, 43.8; proteins, 5.8; carbohydrates, 34.8; and ether extr., 1.4%; and nutritive ratio, 6.6. Two flavonoids, quercetin and a quercetin-3-disaccharide (sugars identified being galactose and arabinose), have been isolated from the leaves (Lander, 280; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1964, 66–67, 114–15; Kalra *et al.*, loc. cit.).

The acorns are used in indigenous medicine as diuretic and in gonorrhoea, and also as an astringent in indigestion and diarrhoea, especially of children. They are said to be buried in the earth for sometime before use, so that the tannin and associated substances may be removed by the process of germination. They contain a considerable amount of starch (*c.* 65% on dry basis) but are not fit for human consumption, due to the high content of tannin (*c.* 6%). By repeated extraction of the material with warm water, followed by treatment with lime water and potassium permanganate, an edible flour can be obtained, which contains about 76 per cent of starch. The kernels (81% of acorns) on extraction with petroleum ether gave 16 per cent of a thin, yellow fatty oil with the following characteristics: sp. gr.$^{25°}$, 0.9081; $n^{30°}$, 1.4576; iod. val. (Hanus), 81.5; sap. val., 192.2; acid val., 13.0; acet. val., 14.8; Hehner val., 96.1; and unsapon. matter, 0.8%. The oil had the following fatty acid composition: palmitic, 17.1; lignoceric (?), 0.9; and oleic, 82.0% (Kirt. & Basu, III, 2358; Lander, 280; *For. Res. India*, 1952–53, pt I, 114; 1953–54, pt I, 70; Puntambekar & Krishna, *J. Indian chem. Soc.*, 1934, **11**, 721; Puntambekar & Varma, *Indian For.*, 1934, **60**, 752).

A sweet exudation, known as Oak Manna, said to be collected from the plant in Iran and Iraq, is used in the preparation of confectionery (Harrison, *Kew Bull.*, 1950, 407).

Q. infectoria Olivier GALL OAK, DYERS' OAK

D.E.P., VI(1), 383; C.P., 911; Howes, 1953, 256, Pl. XVI, Fig. 1 & 2.

HINDI—*Majuphal, mazu, muphal;* BENG.—*Majuphal;* TAM.—*Machakai, mashikai;* TEL.—*Machi kaya;* KAN.—*Machikai;* MAL.—*Majakani.*

A small tree or shrub, *c.* 2–5 m. high, native of Greece, Asia Minor, Syria and Iran. Leaves 4–6 cm. long, very rigid, often glabrescent with spinous teeth; acorns cylindrical.

This tree yields the Oak Galls, used widely in dyeing and tanning. These galls which arise as excrescences on the young twigs are caused by the deposition of egg by a small hymenopterous insect, *Adleria gallae-tinctoriae* Olivier. The female fly lays the egg on or in the cambium of a young shoot. The egg develops into a larva and gets surrounded by the tissues of the developing gall. The galls are collected before the escape of the insect and are well dried. They are spherical or pear-shaped and measure 6–50 mm. in diameter. The surface of the mature dry gall may be smooth and shining, as though varnished, and chestnut brown, but more usually it is rough and of a greyish brown colour. When the galls are gathered at the correct stage, i.e. before the insect emerges, the inner tissue is soft, of a deep greenish yellow colour, with a very astringent taste and slightly sweet aftertaste (Howes, 1953, 258).

The galls of this plant as well as of some allied species are imported into India and other countries. They are variously known in trade as *Aleppo Gall, Mecca Gall, Turkey Gall, Levant Gall, Smyrna Gall, Syrian Gall,* etc. They vary generally in size, colour and general appearance. Galls from Asia Minor,

particularly *Aleppo* (*Haleb*) *Galls* have generally proved to be of the best quality and have the highest tannin content. Galls obtained from eastern Europe are commonly known as *Knoppers* or *Acorn Galls*, and are mainly formed on *Q. robur* and other species ; they are quite different in appearance from those of *Aleppo* or *Turkish Galls*. The *Bassorah* (*Basra*) *Galls* said to be collected in the upper reaches of the Tigris or Euphrates rivers in Iraq and shipped frequently to Bombay are sometimes re-exported as *Bombay* or *Indian Galls*. Some of the gall nuts employed in India may be obtained also from some indigenous oaks found in Kumaun, Garhwal and Bijnor forests.

The galls contain tannic acid (gallotannic acid) as the principal constituent (50–70%). They also contain gallic acid, ellagic acid, gum, starch, sugar and essential oil (Thorpe, V, 425).

Gall nut is used externally for its astringent effect ; it is used in ointments for the treatment of piles, and in plasters. The tannic and gallic acids extracted from the galls are often used in dysentery and diarrhoea and as a gargle. The galls are said to find extensive application in tanning, dyeing, mordanting and in the manufacture of ink (Burkill, II, 1850 ; U.S.D., 1955, 1772 ; B.P.C., 1963, 327 ; Steinmetz, I, 224 ; Hill, 125 ; Hoppe, 753).

Small quantities of gall nuts, ranging between 18,000 and 70,000 kg., are imported annually into this country, the chief exporting countries being Iran, Lebanon and Turkey (Table 1). There is also some export (Table 2) of gall nuts, a part of which is presumably re-exported while a portion may consist of gall nuts derived from species of *Quercus* indigenous to this country.

TABLE 1—IMPORT OF GALL NUTS INTO INDIA

(Qty in kg. and Val. in Rs.)

	Countries of origin					
	Iran	Lebanon	Turkey	Others	Total Qty	Total Val.
1962–63	1,763	7,525	8,782	376	18,446	56,273
1963–64	29,793	5,210	9,975	100	45,078	207,672
1964–65	23,670	12,943	4,549	106	41,268	212,000
1965–66	40,141	..	..	..	40,141	188,981
1966–67*	67,758	..	..	3,813	71,571	375,204

* Data for the period June 1966 to March 1967.

TABLE 2—EXPORTS OF GALL NUTS FROM INDIA

(Qty in kg. and Val. in Rs.)

	Qty	Val.	Chief importing countries
1962–63	42,554	12,361	West Pakistan and Burma
	1,775*	6,387	Burma, West Pakistan and Saudi Arabia
1963–64	7,589	24,483	Japan and Lebanon
	3,601*	11,464	Aden, Burma and West Pakistan
1964–65	2,426	8,165	Aden, Br. Guiana and Singapore
1965–66	5,557	32,461	Burma and France
1966–67	5,001	38,506	United Arab Republic
	300*	1,950	Indonesia

* Re-exports.

Q. lamellosa Sm.

D.E.P., VI(1), 384 ; C.P., 911 ; Fl. Br. Ind., V. 606 ; Troup, III, 945, Fig. 366.

Nepal -*Shalshi, pharat-singhali, bujrat* ; Lepcha *Buk*.

A very large evergreen tree, attaining a height of 30–35 m., and a girth of 6–9 m., with a clean bole of 9–12 m. found in the eastern Himalayas from Nepal to Bhutan, and in Naga and Duffla hills in Assam and in Manipur at altitudes of 1,500–2,700 m. Bark grey-brown with rough spots ; leaves broadly oblong to lanceolate, sharply serrate ; male spikes solitary, female flowers solitary or in short spikes ; acorns stalkless.

This tree is common in Darjeeling district between 2,100 and 2,700 m. in mixed forests. It flowers in April–May and acorns ripen in November–December in the second year. It coppices very well. It does not produce root suckers and natural reproduction is not very good, as large quantities of acorns are eaten by wild animals or destroyed by insects. Direct sowing is preferred for artificial reproduction. The trees develop well with full overhead light from the sapling stage onwards. It is hardy to frost and drought, but very susceptible to damage by fire. Its mean annual girth increment is about 1.2–2.0 cm. It has been cultivated in tea estates in the Darjeeling area for supply of firewood, but has been found to be rather slow. Many beetles and larvae bore into dead wood [Troup, III, 945–49 ; Gamble, 678 ; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 97 ; Mathur & Balwant Singh, *Indian For. Bull.*, *N.S.*, No. 171(7), 1959, 100].

The wood is light russet to greyish brown, heavy to very heavy (sp. gr., *c.* 0.95 ; wt., 689–961 kg./cu.m.), fairly straight- to more or less irregularly-grained, medium coarse- and uneven-textured. It is liable to

form end splits. It is a refractory timber and is only partially treatable. Green conversion, close stacking and slow seasoning are advocated. The timber is durable, unless placed in damp conditions. It is hard to work and saw, and difficult to manipulate with hand tools, but finishes well. The data for the comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 125; strength as a beam, 105; stiffness as a beam, 120; suitability as a post, 95; shock-resisting ability, 130; retention of shape, 45; shear, 145; and hardness, 140 [Pearson & Brown, II, 996; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, **1**, 96; Trotter, 1944, 254].

The wood is regarded as a heavy construction timber and used for posts and beams in the construction of houses and bridges; it is also used for door posts, window frames and rafters and for agricultural implements and cart wheels. It is a good firewood (calorific value: sapwood—5,150 cal., 9,270 B.t.u.; heartwood—5,180 cal., 9,324 B.t.u.) (Pearson & Brown, II, 996; Gamble, 678; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22).

The bark (tannin, 12.6%) is used for tanning. The bark and acorns are astringent in action and are used in medicine [Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145; Hooper, *Agric. Ledger*, 1902, 55].

Q. lanata Sm. syn. *Q. lanuginosa* D. Don
WOOLLY OAK

D.E.P., VI(1), 384; Fl. Br. Ind., V, 603.

NEPAL—*Banga*; KUMAUN—*Ranj*, *raibanj*; GARHWAL—*Kiani*.

A large evergreen tree, up to *c.* 25 m. tall, found from Kumaun eastward to Bhutan and N.E.F.A., at altitudes of 1,200–2,400 m. Bark grey or brown, rough and irregularly exfoliating; young shoots woolly; leaves oblong- or ovate-lanceolate; male catkins densely woolly, female flowers 2–5 on a common peduncle; acorns sessile, in clusters of 2–5.

The distribution of this tree is very local, but it often occurs in dense pure patches. It is also found associated with *Q. incana*, *Q. dilatata*, *Rhododendron arboreum*, *Pinus roxburghii*, etc. It is more light-demanding, but less exacting as to soil and exposure than *Q. dilatata*. It coppices well. It resembles *Q. incana* as to conditions for successful natural reproduction. Artificial reproduction can be carried on successfully both by direct sowing and by transplanting from the nursery (Troup, III, 935).

The wood (wt., 850–930 kg./cu.m.) is greyish brown in colour, very hard, but apt to warp and split. It is used as fuel. The leaves and young twigs are lopped for fodder (IS: 399–1952, 7).

Q. lanceaefolia Roxb. syn. *Castanopsis lanceaefolia* Hickel et A. Camus

D.E.P., VI(1), 384; Fl. Br. Ind., V, 616.

NEPAL—*Patle katus*; LEPCHA—*Siri*; ASSAM—*Bucklai*; GARO—*Shingra, chauko*; KHASI—*Dingsning*.

A small evergreen tree found in the sub-Himalayan tract of Sikkim and Bhutan up to 1,500 m. and extending into Assam, Khasi hills and Manipur. Bark greyish brown, with close fissures and cracks; leaves lanceolate, or oblong-lanceolate; flowers in spikes in large terminal tomentose panicles. The wood (wt., 721–961 kg./cu.m.), which is greyish white and hard, is used in Assam for building purposes. The acorns are said to be used as bait for catching birds. The bark contains 10–11, leaves 6–21 and wood 1–3 per cent of tannin [Gamble, 681; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145].

Q. lineata Blume

Fl. Br. Ind., V, 605.

NEPAL—*Phalat*; LEPCHA—*Siri*.

A small or medium-sized tree found in the eastern Himalayas at altitudes of *c.* 1,800–2,700 m. and in Khasi and Naga hills in Assam. Bark thick, grey-brown; leaves oblong- or ovate-lanceolate; male spikes in small fascicles, female spikes on different trees; acorns solitary and sessile.

This is an important tree on the Darjeeling hills where it is commonly associated with *Q. lamellosa*. Natural reproduction suffers due to the attack of acorns by insects and other pests. Artificially, it is reared in the same way as *Q. lamellosa*. It grows comparatively fast. The plant and wood are subject to the attack of some fungi and insects [Gamble, 677; Troup, III, 949; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 292; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 101].

The wood (wt., *c.* 865 kg./cu.m.) is brown or greyish brown and very hard and refractory and is only partially treatable. Graveyard tests showed an average life of six years. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 130; strength as a beam, 105; stiffness as a beam, 120; suitability as a post, 105; shock-resisting ability, 115; retention of shape,

45; shear, 130; and hardness, 160 (Trotter, 1944, 13, 254–55; Gamble, 677; Purushotham *et al., Indian For.*, 1953, **79**, 49).

It is a moderately good fuel wood (calorific val.: sapwood—4,899 cal., 8,818 B.t.u.; heartwood—5,183 cal., 9,330 B.t.u.). The leaves contain 9–11 per cent tannin and bark 15 per cent [Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22; Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 145].

Q. semecarpifolia Sm. BROWN OAK OF HIMALAYA, KHARSHU OAK

D.E.P., VI(1), 385; C.P., 911; Fl. Br. Ind., V, 601; Troup, III, 928–35, Fig. 350–54.

NEPAL—*Ghesi, kasru*; PUNJAB—*Banchar, khareu, klarshu*; KUMAUN—*Karshu.*

An evergreen or sub-evergreen tree, up to 30 m. tall, and with a clean bole 10–12 m. long and *c.* 2 m. or more in girth, found throughout the temperate Himalayas from Kashmir eastwards up to Bhutan and also in Assam and Manipur at altitudes of 1,800–3,600 m.: it often ascends to the upper limit of tree growth. Bark dark grey, rough, exfoliating in irregular woody scales; leaves elliptical or oblong, spinous-toothed or entire; male spikes crowded; female spikes short; acorn subglobose, in clusters of 3 or more, about 2.0–2.5 cm. in diameter.

Kharshu oak forests occur in regions of heavy snowfall and moderate rainfall. The tree does not extend into drier parts of inner Himalayas. It is gregarious and forms pure forests along the tops and upper slopes within its well marked zone. It is associated with spruce (*Picea smithiana*), silver fir (*Abies pindrow*), etc. It is found both on deep rich moist soil in sheltered localities, and on poor rocky ground on the crests of ridges; in the latter areas it is usually stunted and gnarled.

Under natural conditions it reproduces from seeds in great profusion, particularly if abundant overhead light is ensured. It is often suppressed by *Strobilanthes wallichii* Nees, a weed which produces a dense matted growth. The Kharshu oak can be raised artificially by sowing in contour lines or by dibbling. It is a light demander. It coppices and pollards fairly well. The growth of coppice shoots is slow. It can be worked under the system of successive regeneration fellings. It is subject to attack by a large number of rot-causing fungi and larvae that bore into the wood [Troup, III, 928; Bagchee & Ujagar Singh, *Indian For. Rec., N.S., Mycol.*, 1954, **1**, 292; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(1), 1959, 102].

The wood is light pinkish brown to reddish brown, heavy to very heavy (sp. gr., 0.95–1.4; wt., *c.* 850 kg./cu.m.), straight- to irregular-grained, medium fine and uneven-textured. The timber is very hard, of good quality and durable. It is difficult to season and refractory under tools. It cannot be sawn easily, but lends itself to cleaving (Pearson & Brown, II, 983).

Though Kharshu oak is a fine strong timber it is not much used since more valuable and easily worked woods are available in the areas where this oak grows. It is used locally for building purposes, furniture and ploughs. It can be used as a substitute for imported oak from which kegs for maturing whisky are made. The wood can be used for preparation of hardboards. It is a good firewood and an excellent source of charcoal (calorific value: sapwood—4,819 cal., 8,676 B.t.u.; heartwood—4,815 cal., 8,668 B.t.u.) (Pearson & Brown, II, 983; Trotter, 1944, 207; *For.*

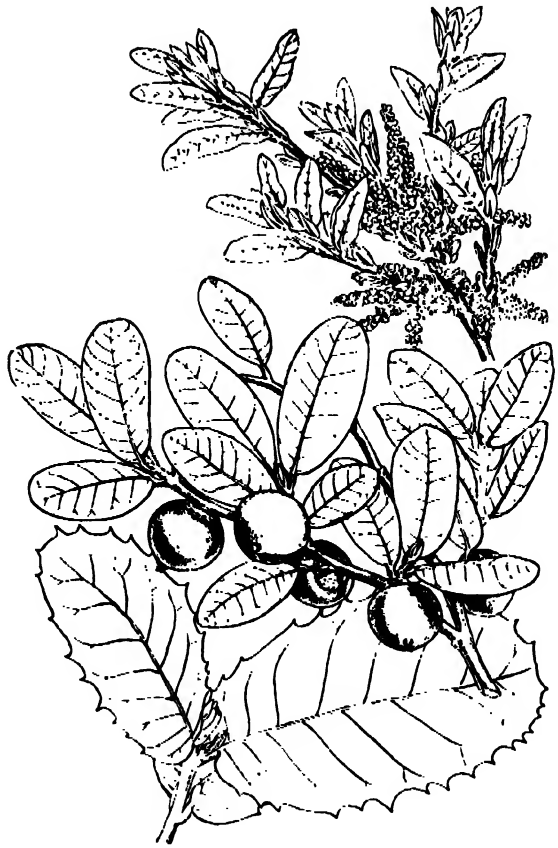


FIG. 130—QUERCUS SEMECARPIFOLIA—FLOWERING AND FRUITING BRANCHES


F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 131—QUERCUS SEMECARPIFOLIA—TRANSVERSE SECTION OF WOOD (×10)

Res. India, 1947 48, pt I, 56; Narayanamurti & Kultar Singh, *Indian Pulp Pap.*, 1961 62, **16**, 543; Krishna & Ramaswami, *Indian For. Bull.*, *N.S.*, No. 79, 1932, 22).

The leaves make an excellent fodder and are also employed as litter; they have been found suitable for feeding the caterpillars of silk moth, *Antheraea pernyi* Guer. Mene., introduced towards the end of the last century from China. The leaves contain 8 per cent and the bark 7 11 per cent tannin. Samples of Kharshu bark are said to have yielded as much as 23.7 per cent of tannin. The bark has been found to be inferior to *Q. incana* bark for tanning purposes. The bark tannin yields protocatechuic acid and oak red [Gamble, 671; Edwards *et al.*, *Indian For. Rec.*, *N.S.*, *Chem. & Minor For. Prod.*, 1952, **1**(2), 145; Troup, III, 929; Wehmer, I, 225].

Q. semiserrata Roxb.

D.E.P., VI(1), 386; Fl. Br. Ind., V, 604.

LUSHAI—*Sehop*; CACHAR—*Ramrotor.*

A large or medium-sized tree, *c.* 30 m. high and 1.5 m. diam., found in Khasi and Garo hills in Assam and in Manipur, up to an altitude of *c.* 1,200 m. Bark grey, rough, hard; leaves oblong to lanceolate; male spikes slender, flowers minute.

The wood (sp. gr., *c.* 0.99; wt., *c.* 820 kg./cu.m.) is reddish brown, straight or somewhat fibrous grained, medium fine but uneven-textured, hard and heavy. It is not difficult to saw and work. The wood is used for plugs or pins of cart wheels (Pearson & Brown, II, 993; Gamble, 677).

Q. suber Linn. CORK OAK

D.E.P., VI(1), 387; Fl. Europaca, I, 62.

A medium-sized evergreen tree with a relatively short trunk, spreading branches and a uniform crown, indigenous to the shore areas of the western Mediterranean region. Bark thick, deeply furrowed, spongy and elastic; leaves ovate to ovate-oblong, sinuate dentate; male flowers in thread-like catkins in groups; acorns of varying sizes and shapes.

Cork is obtained from the bark of this tree, mostly growing wild. The chief cork-producing countries are Portugal, Spain, France and Italy in Europe, and Algeria, Morocco and Tunisia in North Africa. The area under cork forests in this region is estimated at about 2,000,000 hectares, with an average annual production of nearly 340,000 tonnes. Over 80 per cent of world production of cork is contributed by Portugal (*c.* 50%), Spain (*c.* 22%) and Algeria (*c.* 12%), while the neighbouring countries account for the rest (Cooke, G.B., 1–3; Willimott, *World Crops*, 1963, **15**, 172).

Cork oak is a temperate zone tree and thrives in an area with mean annual temperature ranging between 10 and 21°. Climatic conditions which prevail in its native regions, are described as oceanic. It is said to do best on poor soils, where it produces cork of the finest texture. Cork tree can be propagated by seeds sown in nurseries and transplanted in favourable localities. Direct seeding is considered the most economical and successful method. Efforts have been made to establish cork oak forests in many countries and trials in California (U.S.A.) are said to have been very successful. Attempts have also been made to grow cork oak trees in India particularly in the Nilgiris [Cooke, G.B., 13; Willimott, loc. cit.; Bal, *Manufacturer*, 1950, **11**(1), 18; Krishnamurthi, 225; Information from the Central Sylviculturist, Forest Research Institute, Dehra Dun].

Normally, the bark is first stripped from the cork oak trees when they are about 20 years old and thereafter at intervals of 8–10 years, through a productive

life of more than 150 years. The bark after stripping is stacked and left to season for a few weeks, when it dries up and becomes flattened. The bark is then boiled for a short time to remove tannins and other water-soluble materials and finally dried. The yield of cork per tree depends upon many variable factors and may range from 20 to 200 kg. or more (Cooke, G. B., 9, 13–17; Willimott, loc. cit.).

The chief characteristics of cork that render it peculiarly suitable for a variety of uses are its low specific gravity (av. 0.16), compressibility, elasticity, impermeability to both air and water, low thermal conductivity, and remarkable resistance to deterioration. In some cases the natural cork is utilized; in others composition cork, made of coarse or finely ground pieces treated with adhesives and moulded, is used. Cork is extensively employed in the making of bungs and stoppers for bottles and other containers. It is also used in making mats, soles for shoes, linings, artificial limbs, life preservers, novelties and many other articles. Cork waste finds wide application as an insulating material, and is also utilized in the manufacture of linoleum. Wax extracted from the cork waste is of considerable hardness and is used for making shoe pastes (Thorpe, III, 365; Cooke, G. B., 33–60; Warth, 256).

The chemical composition of cork varies according to age, growing conditions and grades of the bark. A good specimen conforms to the following values: moisture, 3–7; fatty acids, 20–38; other acids, 10–18; tannins, 2.0–6.5; glycerin, 1.0–6.5; lignin, 12.6–18.0; cellulose, 1.8–5.0; ceroids (waxes, stearins, etc.), 4.5–15.0; ash, 0.1–4.0; and other substances, 8–21%. Suberin is considered to be the characteristic constituent of cork. It is mainly composed of high molecular polymerides of hydroxy fatty acids, of which phellonic acid (22-hydroxy docosanoic) is the major component. Other fatty acids present are phloionic (9, 10-dihydroxy octadecanedioic), phloionolic (9, 10, 18-trihydroxy octadecanoic) and its stereoisomer (m.p. 133°), *cis*- and *trans*-9-octadecenoic, 18-hydroxy-9-octadecenoic, and several unidentified acids. Crude cork wax contains cerin (chief constituent), friedelin, steroids, acids, etc. (Ribas, *Chim. et Industr.*, 1952, **68**, 333; Thorpe, III, 366; Cooke, G. B., 25–32; Dictionary of Organic Compounds, III, 1685, 1771; IV, 2736; suppl., 1965, 162; *Chem. Abstr.*, 1956, **50**, 806; Warth, 256–58).

India imports some quantities of raw cork ranging between 1,000 and 3,000 tonnes per annum valued at 2–3 million rupees, and smaller quantities of cork manufactures (Table 3).

Q. robur Linn. (ENGLISH OR EUROPEAN OAK) and a closely allied species *Q. sessiliflora* Salisb. are reported to be cultivated in Nilgiris. They are said to grow well. Other exotic species said to be growing in Nilgiris are: *Q. cerris* Linn. (TURKISH OAK), *Q. coccinea* Muench. (LAUREL OAK), *Q. macrocarpa* Michx. (BUR OAK), and *Q. montana* Willd. (CHESTNUT OAK) (Burkill, II, 1849; Krishnamurthi, 224–25; Information from the Curator, Government Botanic Garden, Ootacamund).

Quercus spp. — *see* **Lithocarpus**

TABLE 3—IMPORT OF CORK AND CORK PRODUCTS INTO INDIA

(Qty in tonnes and Val. in thousand Rs.)

	Qty					Val.				
	1962–63	1963–64	1964–65	1965–66	1966–67*	1962–63	1963–64	1964–65	1965–66	1966–67*
Natural Cork										
1. Raw Cork, including natural cork in blocks and sheets	2,056.3	1,382.2	1,950.3	2,996.1	794.4	2,911.5	2,162.9	2,447.6	3,194.7	1,361.9
2. Cork waste	4.0	28.2	301.2	90.4	754.2	5.6	28.8	222.8	114.8	1,291.8
Cork Manufactures										
1. Cork sheets	29.4	71.1	47.7	29.6	51.5	140.7	367.7	213.9	168.6	439.1
2. Other agglomerated cork materials	31.2	11.9	13.6	31.5	70.6	70.4	51.3	79.7	109.4	574.8
3. Cork for bottles	24.1	0.8	1.4	0.1	..	315.3	8.0	12.4	1.1	..
4. Gaskets Cork	2.9	9.9	0.5	..	..	22.7	53.5	5.8	..	..
5. Cork board	2.9	3.3	..	0.3	..	5.7	6.9	..	0.8	..
6. Other articles of cork	79.3	52.1	50.1	69.3	13.4	552.9	473.4	325.6	348.9	74.1

* Data for the period June 1966 to March 1967.

QUILLAJA Molina (*Rosaceae*)

Bailey, 1947, III, 2891.

A small genus of shrubs or trees, native of South America. One species *Q. saponaria* has been introduced into India.

Q. saponaria Molina (Soap Bark, Quillaia Bark) is an evergreen graceful tree, native of the western slopes of Andes in Chile and Peru, and has been introduced into India and grown in the Botanic Gardens, Ootacamund, Nilgiris. It is said to be suitable for growing in cool and moist areas (Krumbiegel, 28 : Information from the Curator, Government Botanic Gardens, Ootacamund).

Q. saponaria is the source of Quillaia bark, used for industrial and medicinal purposes, and is official in I.P. and B.P. The bark consists almost entirely of the saponaceous inner bark (phloem), and is procured from the tree after shaving off the outer bark which contains tannin and colouring matter, but no saponin. Quillaia is marketed in the form of odourless flat pieces, *c.* 1 m. long, 10-20 cm. broad, and 3-10 mm. thick (Trease, 373 : I.P., 514 : B.P., 1963, 692).

The powdered quillaia yields copious lather in water and is used for laundering delicate fabrics : it was one of the best war-time emergency materials for cleaning lenses. It is employed as a detergent, and emulsifying and foaming agent in shampoos, hair tonics and other cosmetics, tar solutions, and metal polishes. It also finds use in fire extinguishing solutions. Medicinally, the bark is reported to be an expectorant and diuretic, and a cutaneous stimulant. Its liquid extract is employed in lotions used as a wash for the scalp in certain skin troubles. When the bark powder is added to beer or soft drinks, it increases their foaming power, but utilization of the bark for this purpose is harmful, as it is a heart and respiratory depressant and causes destruction of red blood corpuscles (Trease, 373 : Hill, 209 : *Econ. Bot.*, 1955, **9**, 303 : Hocking, 186 : Wren, 283 : Youngken, 420 : Allport, 106 : Claus, 1961, 152).

The detergent and medicinal properties of quillaia are due to the presence of one or more haemolytic saponins (9-10%), of which quillaia-saponin (m.p. 207°) is the most important. On hydrolysis, quillaia-saponin yields glucuronic acid and quillaiac acid ($C_{30}H_{46}O_5$, m.p. 294°), a triterpenoid sapogenin (U.S.D., 1955, 1153 : McIlroy, 67).

Quince — *see* **Cydonia**

Quince, False — *see* **Docynia**

Quinine — *see* **Cinchona**

QUISQUALIS Linn. (*Combretaceae*)

A small genus of woody climbers distributed in tropical and South Africa and Indo-Malaysian region. Two species are found in India, of which *Q. indica* is probably introduced, as it is not found growing wild anywhere in India.

Q. indica Linn. syn. *Q. densiflora* Wall. ex Miq.
Rangoon Creeper

D.E.P., VI(1), 388 : Fl. Br. Ind., II, 459 : Fl. Malesiana, Ser. I, **4**(5), 544, Fig. 8 & 9.

Hindi—*Rangoon-ki-bel* ; Guj.—*Barmasi vel* ; Tel.—*Ettaguttilativva, rangonimalle, tige-ganneru* ; Tam.—*Irangunmalli, ilengaramalligai.*

Bombay—*Barmasi, lalachameli, rangunachavel.*

A large, woody, scandent shrub, probably indigenous both in tropical Africa and tropical Indo-Malaysian region, cultivated in gardens throughout India, up to an altitude of 300 m. Leaves opposite or sub-opposite, papyraceous, elliptic or elliptic-oblong, acuminate, entire ; flowers numerous, white

FIG. 132—QUISQUALIS INDICA—FLOWERING BRANCH

or red, fragrant, in axillary or terminal pendulous racemes; fruit dry, coriaceous, ovate-elliptic, 2.5–4.0 cm. × 0.75–1.25 cm., 5-angled or 5-winged, 1-seeded.

Q. indica is a hardy creeper, commonly planted in gardens for its brightly coloured, showy flowers. A few varieties are distinguished, showing variations in flower colour and leaf size. The plant is easily raised from layers, cuttings or divisions of the root. It does well in good soil. It grows rapidly, requiring a strong trellis for its support; it is also grown on an arch or on a tree. It can be kept within bounds as a bush by removing the long new growths. The plant is in profuse blooming almost throughout the year. Flowers appear in constant succession in drooping clusters; they open in the evening as white flowers, gradually assuming a pink tinge by morning and deepening to deep red by late afternoon. They are sweet-scented. The plant rarely bears fruits in northern India (Bor & Raizada, 179–80: Gopalaswamiengar, 362; Percy-Lancaster, *Bull. nat. bot. Gdns, Lucknow*, No. 74, 1962).

Fruits and seeds of *Q. indica* possess anthelmintic properties. Fruits are picked half-ripe when they are bitter, pulped in water and the liquid taken internally; seeds from ripe fruits may also be used. Ripe seeds are sweet and are eaten only in strict moderation. More than 4 or 5 seeds are reported to cause colic in some cases. Seeds possess sporific properties. An overdose causes unconsciousness. In China, ripe seeds are roasted and given in diarrhoea and fever; they are also used for rickets of children in Indo-China. Macerated in oil, seeds are used as an external application to parasitic skin diseases. An oil extracted from the seeds possesses purgative properties (Burkill, II, 1860–61; Monachino, *Econ. Bot.*, 1956, **10**, 42; Kirt. & Basu, II, 1037; Quisumbing, 656).

The anthelmintic properties of the seeds are attributed to the presence of an active principle resembling santonin. The proximate composition of the seeds (wt., 1.0–1.5 g.) is as follows: moisture, 6.5; nitrogenous matter, 10.7; fat, 23.9; N-free extr., 48.6; cellulose, 3.9; and ash, 6.5%. They are also reported to contain malic, citric and succinic acids, unidentified alkaloids and potassium sulphate (3.9%). They yield 23–27 per cent of a clear, yellow fatty oil having the following characteristics: sp. gr.$^{30°}$, 0.907; $n^{30°}$, 1.4585; sap. val., 187–202; iod. val., 59–67; acet. val., 3–21; R.M. val., 1.4; and unsapon. matter, 1.0–1.5%. The fatty acid composition of the oil is: myristic, 4.5; palmitic, 29.2; stearic, 9.1; oleic, 48.2; and linoleic acid, 9%. The fruits contain trigonelline. The deep red flowers contain cyanidin monoglycoside (Claus, 1961, 188; Mensier, 482; Adriaens, 252–54; *Chem. Abstr.*, 1951, **45**, 3564, 5687; 1941, **35**, 4913; Wehmer, II, 822; Eckey, 705; Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B**, 211).

Extracts from the roots and from the leaves are also effective as anthelmintic. The juice of leaves is used by the Malays as a lotion for boils and ulcers. Leaves are used in a compound decoction to relieve flatulence (Burkill, II, 1860; Kirt. & Basu, II, 1037).

In Indonesia, very young shoots are eaten raw or steamed. The long flexible stems are used for basketry, fish weirs and fish traps in Togoland (Burkill, II, 1861; Irvine, 1961, 127–28).

R

Rabbits — *see* **Rodents**

RADERMACHERA Zoll. & Moritzi (*Bignoniaceae*)

A large genus of trees, distributed in the Indo-Malaysian region. Three species occur in India.

R. xylocarpa (Roxb.) K. Schum. syn. *Stereospermum xylocarpum* Benth. & Hook. f. PADRI TREE

D.E.P., VI(3), 367 : Fl. Br. Ind., IV, 383.

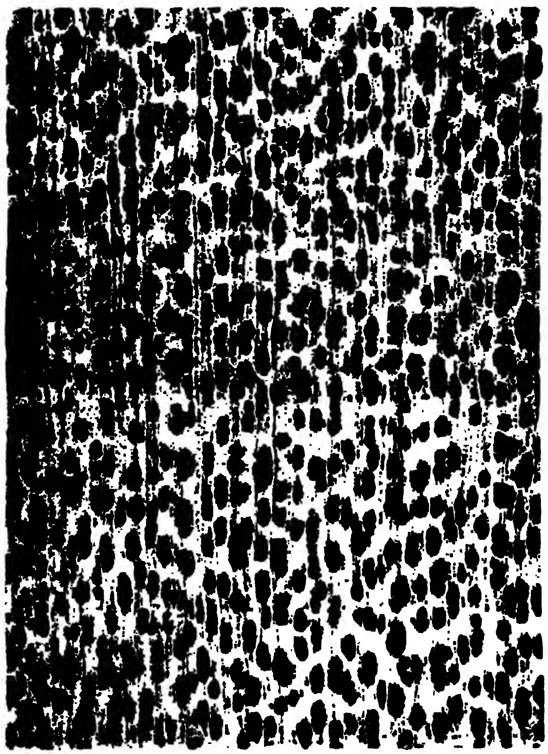
MAR.—*Kharsing, kadashing, bairsinge;* TEL.—*Nagadudilam, warawaili;* TAM.—*Vadencarni, vedanguruni, mulaiutbi, pathiri;* KAN.—*Koonanakoombumura;* MAL.—*Vedangkonna, edangkorna;* ORIYA—*Khonda-partoli.*

MADHYA PRADESH—*Paral, jaimangal;* COORG—*Udi.*

A medium-sized tree, up to 18 m. in height and 2.4 m. in girth, found throughout the Deccan Peninsula up to an altitude of *c.* 1,500 m., extending into parts of Gujarat, Madhya Pradesh, Bihar and Orissa. Bark greyish, flaky; leaves large, up to 1 m. or even more in length, 2- or 3-pinnate: pinnules elliptic to ovate: 5.0–7.5 cm. long; flowers large, fragrant, white tinged with yellow or pink, in dense panicles: capsules cylindric, woody, prominently tubercular, slightly curved, up to 90 cm. long and 3.8 cm. broad: seeds thinly discoid, *c.* 3.2 cm. long including the wings.

The tree occurs usually in deciduous forests. It is a light demander, though young trees tolerate some shade. It produces root suckers. Artificial propagation may be done by sowing seeds which have matured for nearly a year; newly gathered seeds rarely germinate. The seedlings are transplanted at a spacing of 6.0 m. They need irrigation at least in the first dry season. The rate of growth is slow, the annual girth increment being 0.7–1.8 cm. The tree is occasionally planted in gardens and is also grown as an avenue tree, though it becomes leafless for a short period in the beginning of the hot season. The tree is attacked by defoliators [Troup, II, 683; Cameron, 212; *Indian For.*, 1948, **74**, 279; Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(8), 1960, 74].

The sapwood is grey to light brownish grey; heartwood greyish brown when first exposed, with a tendency towards yellow streaks or patches, aging to golden or orange-brown, straight- or irregularly interlocked-grained, medium coarse- and fairly even-textured, hard, moderately strong, tough, elastic and heavy (sp. gr., 0.69: wt., 624–897 kg./cu.m.). There is a tendency to short wavy-grain in some specimens, giving the boards an ornamental appearance resembling teak. It is a medium refractory timber. The wood seasons well with care and is durable: graveyard tests have indicated a durability of 7–10 years. It is easy to saw and work and to turn on a lathe to a fine surface: it takes a good polish. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 100; strength as a beam, 80; stiffness as a beam, 80; suitability as a post, 85; shock-resisting ability, 75; retention of shape, 85; shear, 120; and hardness, 115 (Pearson & Brown, II, 777–80; Trotter, 1944, 15; Krishnamurti Naidu, 105; Limaye & Sen, *Indian*



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 133—RADERMACHERA XYLOCARPA—TRANSVERSE SECTION OF WOOD (×10)

For. Rec., N.S., Timb. Mech., 1953, **1**, 98; Talbot, II, 315; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, **1**, 60, Sheet No. 19).

The wood is used for house building, furniture, carts and carriages, and for agricultural implements. It is suitable also for panelling, packing cases and sleepers. It is a good fuel wood; calorific value: sapwood—5,175 cal., 9,315 B.t.u.; heartwood—5,449 cal., 9,809 B.t.u. (Pearson & Brown, II, 780; Krishnamurti Naidu, 105; Limaye, loc. cit.; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 24).

The tender fruits are reported to be eaten as a vegetable. The plant is credited with antiseptic properties, and a resin, extracted from the wood, is used for the treatment of skin troubles. The root bark is bitter and astringent and evidently used as a substitute for the root bark of *Stereospermum personatum* (Hassk.) D. Chatterjee and *S. suaveolens* DC. (Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 2, 1953, 50–51).

Radish — *see* **Raphanus**

Radish, Horse — *see* **Cochlearia**

Radish Tree, Horse — *see* **Moringa**

Radix Ratanhiae — *see* **Krameria**

Raffia Palm — *see* **Raphia**

Ragi — *see* **Eleusine**

Railway Creeper — *see* **Ipomoea**

Rain Tree — *see* **Enterolobium**

Raisins — *see* **Vitis**

Ramboostan, Rambutan — *see* **Nephelium**

Ramie — *see* **Boehmeria**

RANDIA Linn. (*Rubiaceae*)

A large genus of erect or climbing shrubs and trees distributed in the tropical and sub-tropical regions of the world, especially in Asia and Africa. About 14 species occur in India.

The delimitation of this genus is still not clearly defined. Based on pollen characters and floral morphology, some of the Indian species are now referred to several genera, viz. *Xeromphis* Rafin., *Rothmania* Thunb., *Aidia* Lour., etc. (Keay, *Bull. Jard. bot. Brux.*, 1958, **28**, 15; Maheshwari, *Bull. bot. Surv. India*, 1961, **3**, 91).

R. spinosa Poir. syn. *R. dumetorum* Poir.; *R. brandisii* Gamble; *R. longispina* Wight & Arn.; *R. tomentosa* Wight & Arn., non Blume; *Xeromphis spinosa* Keay

COMMON EMETIC NUT

D.E.P., VI(1), 389; Fl. Br. Ind., III, 110.

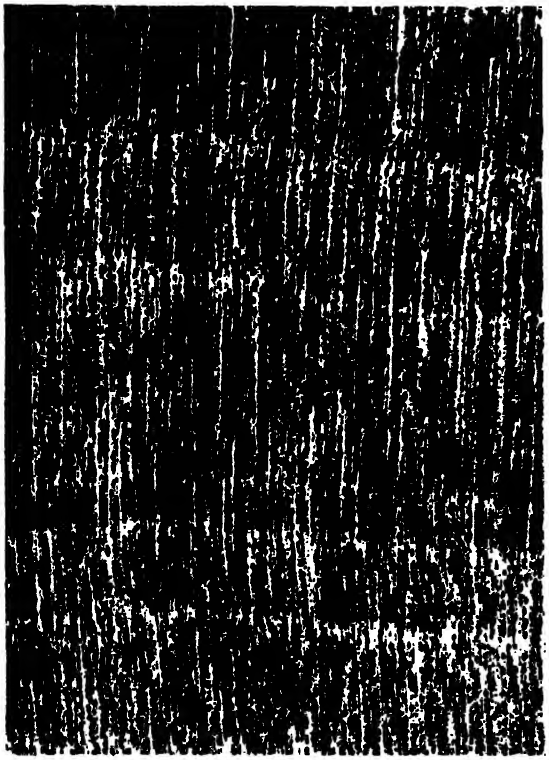
SANS. *Madana*; HINDI, BENG.—*Mainphal*; MAR.—*Ghela, peralu, wagatta, mindhal*; GUJ.—*Mindhal*; TEL.—*Manga*; TAM.—*Marukkallankay, mad karai*; KAN.—*Kare, banegara, mangari*; MAL.—*Kara*; ORIYA—*Patova*.

ASSAM—*Gurol, behmona, mon*; KHASIA—*Dieng-makasing-khlaw*; KUMAUN—*Ghara, rara*; PUNJAB—*Arara*; NEPAL—*Maidal, amuki*; LEPCHA—*Panji, rung-gong-zhu*; KASHMIR—*Kirkla, kokoa*.

A deciduous, thorny shrub or a small tree, up to 9 m. in height and 90 cm. in girth, with a bole 2–3 m. high in favourable localities, found throughout India, up to an elevation of 1,350 m. in the hills. Bark dark brown or grey, rough, scaly; leaves obovate; flowers first white, later turning to yellow, fragrant; berry yellow when ripe, 3.0–3.7 cm. long, globose or broadly ovoid, smooth or obscurely longitudinally ribbed; seeds many, flat, about 4 mm. long, angular.

This species appears to be polymorphic and some authors have split it into three: (*i*) *R. dumetorum*

FIG. 134—RANDIA SPINOSA—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo: Ramesh Rao

FIG. 135—RANDIA SPINOSA—TRANSVERSE SECTION OF WOOD (×10)

sensu stricto, distributed in the eastern coastal districts of Andhra Pradesh and Madras and parts of the Deccan: (*ii*) *R. longispina* Wight & Arn., distributed in North India from Kumaun to Assam, extending southward into the hills of Vishakhapatnam; and (*iii*) *R. brandisii* Gamble, distributed in the Deccan Peninsula, especially in the western parts (Gamble, *Kew Bull.*, 1921, 312: Fl. Madras, 614).

R. spinosa is common as an undergrowth in the sal forests of the sub-Himalayan tract and in many parts of the Indian Peninsula. It is drought-hardy and reproduces by root suckers. Its rate of growth is moderate with a mean annual girth increment of 1.5–2.2 cm. It is subject to attack by many insects [Troup, II, 632; Gamble, 413: Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 107].

The wood is white to light-brown with indistinct heartwood, straight-grained, very fine- and even-textured, moderately durable and moderately heavy (sp. gr., 0.75; wt., 769 kg./cu.m.). The timber is liable to develop end-splits while seasoning. It is durable under cover and moderately so in exposed situations. It is not difficult to saw; it machines and turns well, finishing to a good surface, but is liable to contain numerous small knots. It is used for making walking sticks, umbrella handles, and ploughs. It is considered suitable for cotton-reels and small solid bobbins, mathematical instruments and calico-printing blocks. It is a moderately good fuel wood: calorific value of the wood—4,787 cal., 8,617 B.t.u. (Pearson & Brown, II, 640-42: Gamble, 413: Trotter, 1944, 209, 214, 229; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 22).

Destructive distillation of wood gave (on dry wt. basis): charcoal, 30.0; tar, 10.8; pyroligneous acid, 40.2 (acid, 5.4; ester, 5.0; acetone, 3.7; and methanol, 1.0); pitch and losses, 1.7; and gas, 17.0% (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B**, 217).

The fruits ripen in the cold season. They are eaten after roasting or cooking; the taste of the roasted fruits is said to be like that of almond. Owing to the high tannin content, the fruit has a highly astringent taste and requires prolonged cooking before it can be consumed. The fresh green fruit consists of: outer peel, 19.7; outer hard pulp, 50.6; and inner seedy pulp, 29.7%. The outer and inner pulps have respectively, the following proximate composition: moisture, 74.1, 71.4; ether extr., 0.2, 0.1; protein, 0.9, 0.7; sugars, trace, 5.5; other soluble carbohydrates, 17.7, 6.7; crude fibre, 4.4, 9.5; acids (as citric), 0.3, 0.5; and tannins, 1.6, 5.0%. Presence of pectin, mucilage, and tartaric acid is also reported [Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 134; Siddappa & Bhatia, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952–53, **2**, 16; Wehmer, II, 1167].

The fruit is credited with a number of medicinal properties. The pulp of the fruit, dried and powdered, is said to be a valuable emetic and used as a substitute for ipecacuanha (*Cephaelis ipecacuanha*). In smaller doses, it is nauseant, expectorant and diaphoretic. It is considered to have anthelmintic and abortifacient properties. The fruit is said to be useful as a nervine calmative and antispasmodic. It is esteemed as a domestic remedy for ailments to which children are subject at teething. The unripe pounded fruit as well as the root are used as a fish-poison. The poisonous properties are said to decrease and disappear as the fruits ripen. The fruits are said to be mixed with stored grain to preserve it from the attack of insects. The unripe fruits are also used as soap in some areas (Nadkarni, I, 1047; Watt & Breyer-Brandwijk, 907; Burkill, II, 1863).

The activity of the drug is attributed to the presence of saponins, which occur to the extent of

2–3 per cent in fresh fruits (c. 10% in dried whole fruit). The saponins are concentrated mostly in the pulp. A mixture of two saponins, viz. randia or neutral saponin (m.p. 289–90° decomp.) and randia acid or acid saponin (m.p. 260° decomp.) has been isolated from the pulp ; the two saponins occur in the fruit at all stages of ripening. On complete hydrolysis, both the saponins yield oleanolic acid as the sapogenin. The acid saponin is believed to be the natural prosapogenin of the neutral saponin. It is formed by the combination of oleanolic acid with a molecule each of glucose, fructose and xylose and probably two molecules of glycuronic acid. In a later investigation, a new saponin designated as ursosaponin (m.p. 245–47° decomp.) was isolated from the ethanolic extract of the dried whole fruit ; on hydrolysis it gave ursolic acid and glucose. Besides saponins, the fruit contains a new triterpene (m.p. 225–27°), and acid resin and trace of a pale yellow essential oil with characteristic odour of the drug (Hardikar & Mohiuddin, *Indian J. med. Res.*, 1937–38, **25,** 131 ; Gedeon, *Arch. Pharm., Berl.*, 1952, **285,** 127 ; Varshney & Sannie, *C. R. Acad. Sci., Paris*, 1956, **242,** 2393 ; Atal & Lamba, *Indian J. Pharm.*, 1960, **22,** 120).

The ethanolic extract of the pulp showed a stimulant action on isolated guinea-pig uterus. In experimental animals, crude saponin produced salivation : on contact it caused a generalized irritation of the mucous membranes producing sneezing, vomiting, and bleeding from the urinary tract. The cornea was inflamed and the drug caused haemolysis both *in vitro* and *in vivo*. The perfused frog heart was arrested in a few minutes, or with higher concentrations practically instantaneously. The drug was rapidly detoxicated by the liver. Owing to high saponin content and haemolytic index (8,540) of the fruits, further investigation on their possible use as expectorant and as substitute for roots of *Polygala senega* has been suggested (Jamwal & Anand, *Indian J. Pharm.*, 1962, **24,** 218 ; Hardikar & Mohiuddin, loc. cit. ; Chopra, 1958, 396 ; Atal & Lamba, loc. cit.).

The fruit extracts exhibit insecticidal and insect-repellent properties. They could possibly be used as synergists in insecticidal preparations (Jacobson, 215 : Abrol & Chopra, *Bull. reg. Res. Lab., Jammu*, 1963, **1,** 156).

The fruits are used as a colour intensifier in calico-printing ; they are said to be used in China to produce a yellow dye.

The seeds are said to be used as tonic to induce appetite. They are reported to be free from saponins. They contain fat (1.5%), protein (14.2%), mucilage, resin, organic acid (1.4%) and a minute quantity of an unidentified alkaloid. The seed fat (Randia fat) is yellowish green in colour, with the consistency of butter and the following characteristics: m.p., 28–29° ; sp. gr.$^{20°}$, 0.9175 ; acid val., 13.8 ; sap. val., 160.2 ; and iod. val., 43.2 (Bressers, 76 ; Hardikar & Mohiuddin, loc. cit. ; Wehmer, II, 1167 ; Krishna *et al.*, *Indian For. Rec., N.S., Chem.*, 1936, **1,** 41).

The bark is astringent and is given in diarrhoea and dysentery. An infusion of the bark is used as an emetic. It is also reported to be abortifacient. It is given internally and also applied externally in the form of a paste in rheumatism and to relieve pain of bruises and bone-ache during fevers ; it is considered a sedative and nervine carminative. The bark contains scopoletin, *d*-mannitol, and a mixture of saponins. The saponins on hydrolysis yield glucose, xylose, rhamnose, and two triterpenic acid sapogenins designated as randialic acid A [19(α)-hydroxyursolic acid, $C_{30}H_{48}O_4$; methyl ester, m.p. 200–02°] and randialic acid B (19-dehydroursolic acid, $C_{30}H_{46}O_3$; m.p. 256–57°) (Kirt. & Basu, II, 1274 ; Nadkarni, I, 1047 ; Haines, IV, 433 ; Chopra, Nayar & Chopra, 209 ; Modi, 316 ; Tandon, *Indian J. Chem.*, 1966, **4,** 483).

The roots possess marked insecticidal and insect-repellent properties. Ten per cent aqueous extract of the roots sprayed against the green-scale (*Coccus viridis* Gr.) of coffee recorded 80 per cent mortality of the insects in four days. The roots are also used as fish-poison. The roots contain scopoletin and *d*-mannitol (Jacobson, 215 ; *Chem. Abstr.*, 1936, **30,** 803, 804 ; Govindachari *et al.*, *J. sci. industr. Res.*, 1959, **18B,** 175 ; Anjaneyulu *et al.*, *Indian J. Chem.*, 1965, **3,** 237).

The plant is readily browsed by goats, and is lopped for fodder in Uttar Pradesh, Assam and Maharashtra. Analysis of the leaves gave the following values (on dry wt. basis): ether extr., 5.7 ; protein, 3.9 ; dig. carbohydrates, 70.0 ; fibre, 11.0 ; ash, 8.5 ; calcium, 2.8 ; phosphorus, 0.04 ; and iron, 0.5% (Troup, II, 632 ; Laurie, *Indian For. Leafl.*, No. 82, 1945, 10 ; Lander, *Misc. Bull., imp. Coun. agric. Res.*, No. 16, 1942, 84).

The flowers yield an essential oil with fragrance reminiscent of Gardenia oil, but the perfume is not commercially prepared. The honey obtained from them is golden yellow in colour and contributes nearly 25 per cent of the honey gathered annually from the western ghats (Khan, *Pakist. J. For.*, 1958,

8, 342 : Chaubal & Deodikar, *Indian Bee J.*, 1965, **27,** 6).

R. uliginosa DC.

D.E.P., VI(1), 391 : Fl. Br. Ind., III, 110 : Talbot, II, Fig. 340.

Hindi—*Pindalu, panar, katul ;* Beng.—*Piralo ;* Mar.—*Pendari, telphetru, phetra ;* Guj.—*Gangeda, gengdi ;* Tel.—*Nalla kakisha, nallaika, goanka ;* Tam.—*Wagatta, perunkarai ;* Kan.—*Kare ;* Mal.—*Fannikara ;* Oriya—*Pendra.*

Assam—*Bon-bongana ;* Kumaun—*Pindru ;* Garhwal—*Mainphal ;* Nepal—*Maidal.*

A deciduous armed tree with quadrangular branches, up to 7.5 m. in height and 1.2 m. in girth, found nearly throughout India, up to 1,000 m. in the hills. Bark reddish brown, scaly ; leaves obovate or obovate-oblong ; flowers dimorphic, white, and fragrant ; berry ellipsoid or ovoid, 5–6 cm. long, yellowish brown, crowned with persistent calyx ; seeds about 12, compressed, smooth, closely packed in pulp.

The plant is common in the sub-Himalayan tracts from the Yamuna eastwards and in eastern, central and southern India. It freely produces root suckers, and is hardy against frost and drought. The rate of growth is moderate, with a mean annual girth increment of 14–28 mm. Several defoliators and borers attack this tree [Troup, II, 632 : Gamble, 413 : Talbot, II, 97 : Mathur & Balwant Singh, *Indian For. Bull., N.S.*, No. 171(7), 1959, 108].

The wood is whitish grey or light-brown, close-grained, hard and fairly heavy (wt., 720–833 kg./cu.m.) and without heartwood. It is not used for any special purpose, but is one of the possible box-wood substitutes ; it is suitable for turning small articles (Gamble, 412–13 : Talbot, II, 97 : Khan, 197).

Destructive distillation of wood gave (on dry wt. basis): charcoal, 30.4 ; tar, 9.6 ; pyroligneous acid, 39.7 (acid, 5.0 ; ester, 3.7 ; acetone, 2.7 ; methanol, 1.4) ; pitch and losses, 1.7 ; and gas 18.5% (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B,** 217).

The fruits ripen in February–March and are eaten boiled or roasted, either alone or in curries. Analysis of the edible matter gave the following values: moisture, 81.7 ; protein, 1.0 ; fat, 0.2 ; fibre, 3.9 ; other carbohydrates, 12.5 ; and mineral matter, 0.7 g. ; calcium 33 mg. ; phosphorus, 13 mg. ; and calorific value, 56 cal./100 g. (Nutritive Value of Indian Foods, 72, 108).

The unripe fruit is astringent. The roasted pulp is used as a remedy in diarrhoea and dysentery, especially during pregnancy. It is used in dyeing as a colour intensifier. The unripe fruit is employed as fish-poison. The fruits, like those of *R. spinosa*, contain a saponin of oleanolic acid, which appears to be responsible for their toxicity to fish. They also contain mannitol and leucocyanidin (Jain, *Curr. Sci.*, 1965, **34,** 505).

The roots are considered to possess cooling, diuretic, and tonic properties. They are employed in biliousness and boils in children and in diarrhoea and dysentery (Datta & Mukherji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 69).

The leaves are boiled and eaten. They are used as fodder for deer and cattle.

Flowers yield an essential oil similar to Gardenia oil, but the perfume is not commercially prepared (Khan, *Pakist. J. For.*, 1958, **8,** 342).

R. candolleana Wight & Arn. (Tel.—*Konda manga ;* Kan.—*Mahagare, bettamangare*) is a small tree, found on very dry stony hills in South India from the Circars to the edge of the Mysore Plateau. The wood is light-brown, close- and even-grained, hard and heavy (wt., 961 kg./cu.m.) (Gamble, 414).

R. cochinchinensis Merrill syn. *R. densiflora* Benth. ; *R. racemosa* F. Vill. (Khasi—*Dieng-iong-blei*) is a large shrub or a small tree, sometimes up to 18 m. high, found in Assam, the Naga and Khasi hills, Travancore and the Andaman and Nicobar Islands. The wood is pale-brown with a light-red or light-purple tinge, hard, heavy (av. wt., 828 kg./cu.m.) and durable. It is reported to be used for house construction in Malaya and for marquetry in Indo-China. In Christmas Islands, it is used for walking sticks and umbrella handles. In Cambodia, the wood and the bitter bark are used in the treatment of fever. A decoction of the roots is used in bowel complaints. The fruit is also said to be used medicinally (Parkinson, 190 : Burkill, II, 1863 : Desch, 1954, 488).

R. exaltata Griff. is a medium-sized to tall tree with a slender trunk, found commonly in the Andamans. The wood (wt., 542–657 kg./cu.m.) is light-brown with a pink tinge, and apparently not durable. In Indo-China, the fruits are used in the preparation of a black dye (Burkill, II, 1864 : Desch, 1954, 448).

R. fasciculata DC. (Assam—*Hohru-majan, pulikaint*) is a thorny, spreading shrub or a small tree, found in the Himalayas from Nepal to Bhutan and Assam, up to an altitude of 1,200 m. The wood is cream coloured or light-greyish brown, hard and close-grained. The leaves of the plant are reported to

be used for poulticing sores (Fl. Assam, III, 60; Gamble, 412; Burkill, II, 1865).

R. gardneri Thw. (TAM.—*Padarappan*) is a medium-sized unarmed tree with white flowers, found in the evergreen forests of Kerala, at altitudes of 150–450 m. The wood is light-yellowish brown, close-grained, moderately hard and heavy (wt., 929 kg./cu.m.). It takes fine polish but is seldom used (Bourdillon, 193).

R. longiflora Lam. (ASSAM—*Pulikaint, borokiamkora*) is a large rambling variable shrub, up to 3 m. in height, with fragrant flowers and obscurely ribbed berries 8–14 mm. long, found in Assam and the Andamans. The wood is cream coloured. The fruits are used medicinally in Indo-China (Fl. Assam, III, 58; Kirt. & Basu, II, 1277).

R. macrantha DC. syn. *Euclinia longiflora* Salisb. is a tree, up to 6 m. in height and 30 cm. in girth, a native of tropical Africa, introduced and grown for its large, fragrant, trumpet-shaped flowers. It can be propagated through layering. The black fruit pulp is edible (Gopalaswamiengar, 285; Irvine, 1961, 671).

R. malabarica Lam. (TEL.—*Pedalli, pedda malle*; TAM.—*Pudan*) is an erect, much branched, thorny shrub, found in Orissa and southwards in most areas of the peninsula, usually in dry, evergreen scrub forest. The plant is used for fencing, and is considered very useful for afforestation. The wood is greyish white, close-grained, hard and heavy (wt., 673 kg./cu.m.). It is used as fuel. The roots contain scopoletin (Gamble, 414; Govindachari *et al.*, *J. sci. industr. Res.*, 1959, **18B**, 175).

R. tetrasperma Benth. & Hook. f. syn. *Aidia tetrasperma* (Roxb.) Yamazaki (KUMAUN—*Ghara*; PUNJAB—*Kikra*) is a small, erect or procumbent shrub with fragrant flowers, found in the sub-tropical Himalayas from Kashmir to Sikkim and Bhutan and in Assam, up to an elevation of 2,000 m. The plant is browsed by goats, and is often reduced to a dense compact bush. The wood is light-greyish brown, close- and even-grained, hard and heavy (wt., 897 kg./cu.m.). The straight branches are suitable for making walking sticks (Gamble, 412; Troup, II, 632; Gupta, 273).

R. wallichii Hook. f. (KHASIA—*Dieng-soh-lakhaishree*) is a tree, up to 15 m. high, found in Bhutan and Assam hills, at altitudes of 300–1,200 m. The wood is cream coloured and much prized in some parts of Assam (Fl. Assam, III, 61).

Rangoon Bean — *see* **Phaseolus**

Rangoon Creeper — *see* **Quisqualis**

RANUNCULUS Linn. (*Ranunculaceae*)

A large genus of annual or perennial herbs, distributed chiefly in the northern temperate regions. About 26 species occur in India.

The members of this genus are popularly known as BUTTERCUPS or CROWFOOTS and some of them are grown as ornamentals. Several of them possess vesicant and toxic properties, the toxic principle being destroyed on drying or boiling. The expressed juice, steam distillate and saline extracts of some species are reported to possess antibacterial, antifungal and antimalarial activity [Jindal, *Indian Hort.*, 1961–62, **6**(1), 27; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(1), suppl., 9; Seegal & Holden, *Science*, 1945, **101**, 413; *Biol. Abstr.*, 1950, **24**, 2274].

R. arvensis Linn. CORN BUTTERCUP

D.E.P., VI(1), 392; Fl. Br. Ind., I, 20; Blatter, I, Pl. 2, Fig. 8.

PUNJAB—*Chambul.*

An erect, much branched, annual herb, up to 60 cm. high, found in the western Himalayas from Kashmir to Kumaun as a weed in cultivated fields during winter season; it is also recorded from Mt. Abu. Leaves radical and cauline, the former long-stalked and spathulate, the latter short-stalked and deeply divided into 2 or 3 narrow segments; flowers pale yellow; fruit a globose head of 5–10 flattened, spinous achenes.

The herb is reported to be used in intermittent fevers, gout and asthma. It is greedily eaten by sheep and goats but is sometimes fatal to them (Kirt. & Basu, I, 16; Stewart, 5).

The herb possesses antibiotic activity. The active principle protoanemonin (0.54%) and its glucosidic precursor, ranunculin, have been isolated. The herb yields hydrocyanic acid in very small amounts (*Chem. Abstr.*, 1957, **51**, 6928; Hill & Van Heyningen, *Biochem. J.*, 1951, **49**, 332; Shearer, *Vet. J.*, 1938, **94**, 22; Chopra, Nayar & Chopra, 209).

R. sceleratus Linn. CELERY-LEAVED CROWFOOT, BLISTER BUTTERCUP

D.E.P., VI(1), 392; Fl. Br. Ind., I, 19; Kirt. & Basu, Pl. 5A.

DELHI—*Jaldhania*; KUMAUN—*Shim*; MUNDARI—*Bir-mani.*

An erect, succulent herb up to 90 cm. high, found in the plains of northern India and in the warm valleys of the Himalayas from Kashmir to Assam, up to an altitude of 1,500 m. Leaves 3-partite, radical leaves long-stalked, and cauline leaves short-stalked

or sessile, deeply divided ; flowers small, pale yellow ; fruit oblong-ovoid, 6–9 mm. long, achenes many.

The fresh plant is highly acrid and produces violent effects if taken internally. It is reported to cause blisters on skin even on touching, and inflammation of the digestive tract when cattle feed upon it. If eaten in large quantities, it is even fatal. Smaller quantities cause reduction of milk yield and impart a bitter taste, unpleasant flavour and smoky red colouration to the milk. The toxic properties are destroyed on drying or boiling. The dried plant included in hays is non-toxic. The boiled herb is said to be consumed as vegetable (Chopra *et al.*, I, 117 ; Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 20 ; Jacobs & Burlage, 183 ; Shearer, *Vet. J.*, 1938, **94,** 22).

The plant is used as a stimulant and diuretic. The juice has caustic properties and is rubefacient ; it

FIG. 136—RANUNCULUS SCELERATUS—FLOWERING BRANCH

is used in sciatica, rheumatism, dysuria, asthma, pneumonia and gripe. The drug is said to be useful as vermifuge, antispasmodic and anodyne. In popular medicine and in homoeopathy it is used against skin disorders (Kirt. & Basu, I, 15 ; Dymock, Warden & Hooper, I, 38 ; Jacobs & Burlage, 183 ; Hoppe, 761 ; Steinmetz, II, 376).

The vesicant properties of the fresh plant are attributed to a substance called protoanemonin (anemonol or ranunculol), which is present in all parts of the plant except seeds. Protoanemonin ($C_5H_4O_2$) is obtained on steam distillation of the fresh plant as an extremely acrid and lachrymatory, yellow, volatile oil ; its yield from the plant just after the full bloom was 0.38 per cent on fresh and 2.50 per cent on dry weight basis. It occurs in the form of a glucoside, ranunculin ($C_{11}H_{16}O_8$), which breaks down enzymically in the crushed tissues liberating protoanemonin and glucose. Protoanemonin is the lactone of γ-hydroxyvinylacrylic acid, and readily dimerizes in air to crystalline anemonin ($C_{10}H_8O_4$), which is also unstable and spontaneously decomposes to keto acids like anemonic acid ($C_{10}H_{12}O_6$). A more recent investigation of the fresh plant has shown the presence of 5-hydroxytryptamine, seratonin, which is a potent vaso-constrictor. The plant also contains six other tryptamine derivatives and two unidentified anti-5-hydroxytryptamine derivatives (Shearer, loc. cit. ; Hoppe, 761 ; Connor, loc. cit. ; *Chem. Abstr.*, 1947, **41,** 2463 ; Hill & Van Heyningen, *Biochem. J.*, 1951, **49,** 332 ; Bhargava *et al.*, *Brit. J. Pharmacol.*, 1965, **25,** 743 ; West *et al.*, 1966, 1321).

Protoanemonin possesses strong antibacterial, antiviral, cytopathogenic, and vermicidal properties ; anemonin is also effective but to a lesser degree. Similar to penicillic acid, protoanemonin is active against both Gram-positive and Gram-negative bacteria. It inhibits the growth of *Escherichia coli, Staphylococcus aureus* and *Candida* (*Monilia*) *albicans*. It inactivates *in vitro* diphtheria toxin (Baer *et al.*, *J. biol. Chem.*, 1946, **162,** 65 ; *Chem. Abstr.*, 1962, **56,** 15612 ; Hoppe, 760).

The seeds are used as tonic and stomachic to destroy foul breath. They are also prescribed in kidney troubles. They contain about 18 per cent protein and 26 per cent fatty oil ; the presence of an alkaloid is indicated (Roi, 359 ; Kirt. & Basu, I, 14 ; Jones & Earle, *Econ. Bot.*, 1966, **20,** 135).

R. cantoniensis DC. syn. *R. pensylvanicus* Hook. f. & Thoms. non Linn. f. is a hirsute herb, up to 90 cm. high, with 3-partite deeply segmented radical leaves

and yellow flowers, commonly met with as a weed from Punjab to Assam, ascending up to an altitude of 1,700 m. It is said to show antibacterial activity of low potency against *Escherichia coli*. It is used as a vesicant (Gaw & Wang, *Science*, 1949, **110**, 11 ; Kirt. & Basu, I, 16).

R. falcatus Linn. is a smooth or slightly woolly herb with 3-fid or pinnatifid radical leaves, and yellow flowers, distributed in the temperate Himalayas from Kashmir to Punjab. The plant is used as a vesicant (Kirt. & Basu, I, 17).

R. laetus Wall. ex Royle syn. *R. cassius* auct. non Boiss. is a much branched erect hairy perennial with a woody rootstock found in temperate Himalayas and common in the inner ranges of Sikkim. Its properties have not been investigated but it is said to be closely allied to and perhaps a variety of the European species, *R. acris* Linn., well known for its acrid and toxic properties (Chopra *et al.*, I, 115).

R. lingua Linn. (GREAT SPEARWORT) is a robust moisture loving or aquatic herb with a creeping rootstock and large yellow flowers found in the temperate Himalayas of Kashmir. The plant causes irritation to the mucous membrane and inflammation of the intestinal tract in livestock but toxicity is said to be lost on drying. The toxic agent is protoanemonin (0.23% on fresh wt.). The leaves are applied as a vesicant in rheumatism of the joints (Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 16 ; Shearer, *Vet. J.*, 1938, **94**, 22 ; Kirt. & Basu, I, 14).

R. muricatus Linn., is an erect or diffuse herb, *c.* 60 cm. in height, with long-stalked cordate radical, and cuneate cauline leaves, met with in moist situations in Kashmir and Punjab and also in the Nilgiris and Kodaikanal hills in South India. It is said to possess acrid, narcotic, rubefacient and vesicant properties. It is used in intermittent fevers, gout and asthma. The herb is said to be poisonous (Jacobs & Burlage, 182 ; Kirt. & Basu, I, 17 ; Webb, *Bull. Coun. sci. industr. Res., Aust.*, No. 232, 1948, 137).

R. trichophyllus Chaix syn. *R. aquatilis* Linn. var. *trichophyllus* Hook. f. Thoms. (WATER CROWFOOT ; WATER FENNEL) (KASHMIR—*Hill, tohlub*) is an aquatic perennial herb with highly dissected submerged leaves and white flowers, distributed from Kashmir to Sikkim. It is found in the plains and hills up to elevations of *c.* 4,500 m. The plant contains negligible amounts of toxic principle and is recommended as fodder. The herb is used in intermittent fevers, rheumatism and asthma (Kirt. & Basu, I, 14 ; Jacobs & Burlage, 181).

Rape — *see* **Brassica**

RAPHANUS Linn. (*Cruciferae*)

A small genus of annual to perennial herbs distributed chiefly in the Mediterranean region. One species, *R. sativus* (Radish), is cultivated throughout the world for its roots which are used as vegetable.

R. caudatus Linn. syn. *R. sativus* var. *caudatus* (Linn.) Vilmorin ; *R. sativus* var. *mougri* Helm ; *R. raphanistrum* subsp. *caudatus* (Linn.) Thell.

RAT-TAIL RADISH

D.E.P., VI(1), 394 ; C.P., 912 ; Fl. Br. Ind., I, 166.

HINDI *Sungra, singri, mungra**.

An annual with purplish glaucous stem which is at first erect and then prostrate, cultivated in northern and western India. Basal leaves long, lyrately pinnate or pinnatisect, coarsely toothed ; cauline leaves simple, linear ; flowers purplish veined ; pods soft, slender, up to 75 cm. in length with an irregularly beaded appearance when mature, with one chamber inside ; seeds few, widely spaced.

This species is said to be a native of Java. Some authors are of the opinion that it is a cultigen of *R. sativus* which has been bred in tropical gardens ; others are of the opinion that the rat-tail radish and the Indian group of radishes have both evolved from some special wild forms formerly spread on the coasts of India and the islands of south-eastern Asia, and which disappeared later [Schulz in Das Pflanzenreich, Heft 70, 1959, 208–09 ; Sinskaia, *Bull. appl. Bot. Pl.-Breed.*, 1931, **26**(2), 37 ; Burkill, II, 1866].

The rat-tail radish is very similar to the common radish but does not produce the characteristic fleshy root. It is grown for its long slender pods which are eaten raw as salad or cooked as vegetable. The method of cultivation is in general similar to that followed in the case of the common radish (cf. *R. sativus*). Seeds are sown usually during August–September in lines keeping an interval of 25 cm. between plants and 75 cm. between lines. The crop comes to flower a month later and the first pods can be picked 6 weeks after sowing. The samples of pods of the rat-tail radish, commonly met with in the local bazaar, are usually not more than 20–25 cm. long but there are also forms under cultivation with pods over 60–75 cm. long.

The pods of the rat-tail radish contain: moisture, 92.3 ; protein, 1.3 ; fat, 0.3 ; fibre, 1.1 ; other carbo-

* The pods of the rat-tail radish and those of the ordinary radish are variously called *sungra* or *mungra* but the use of these names is not always consistent.

FIG. 137—RAPHANUS CAUDATUS—FULL GROWN PLANT IN FRUIT

hydrates, 4.3; and minerals, 0.7%; calcium, 78; and phosphorus, 24 mg./100 g. They contain the pigment malvidin chloride glucoside (Nutritive Value of Indian Foods, 59, 95; Lele, *J. sci. industr. Res.*, 1959, **18B**, 243).

R. sativus Linn. RADISH

D.E.P., VI(1), 393; Fl. Br. Ind., I, 166.

SANS.—*Mulaka*; HINDI, BENG., MAR. & GUJ.—*Muli, mula, mura, muri*; TEL., TAM., KAN. & MAL.—*Mullangi*.

An annual or biennial bristly herb with a white or brightly coloured tuberous tap root, cultivated throughout India and up to 3,000 m. in the Himalayas and other hilly regions. Stems simple or branched, erect, 20–100 cm.; basal leaves long, lyrately pinnate or pinnatisect, coarsely toothed; cauline leaves simple, linear; flowers in long terminal racemes, usually white or lilac with purple veins; fruits inflated, 25–90 mm. long, with a long tapering beak, hardly or irregularly constricted and filled inside with white pith between the seeds; seeds 2–8, globose, yellow or brown.

The cultivated radishes of the various regions of the world are included by most authors under one species, *R. sativus* Linn. Some authors regard it as a sub-species under *R. raphanistrum* Linn. *sensu ampliore*, along with a number of other wild forms of this genus. Some others divide *R. sativus* into more than one species on the ground that it includes well marked groups of radishes differing greatly in morphological and ecological respects from one another, the European types and the Japanese types forming the two extremes, with the Indian types occupying an intermediate position. Thus the wild radish found growing in the coastal regions of Japan and neighbouring regions, as well as the turnip-shaped giant radish cultivated in the Sakurajima Island of Japan, which is presumed to have been derived from it, are together included under *R. raphanistroides* (Makino) Sinsk., and the Indian types are grouped under *R. indicus* Sinsk.,

leaving the European types only under *R. sativus* Linn. *sensu stricto*. *R. caudatus* Linn., the rat-tail radish, is considered to be closely related to the Indian group of radishes, but more tropical in distribution [Mansfeld, 96; Schulz in Das Pflanzenreich, Heft 70, 1959, 194; Sinskaia, *Bull. appl. Bot. Pl.-Breed.*, 1931, **26**(2), 37].

R. sativus is not known in the wild state. It was formerly supposed that all cultivated races of the radish were evolved from *R. raphanistrum* Linn., a widely distributed weed in Europe, but in view of the considerable ecological and morphological differences existing among the cultivated radishes of the different regions of the world, they are now supposed to have been derived from more than one source. The European types of radish are presumed to have sprung directly or through hybridization from some wild species like *R. maritimus* Smith, *R. landra* Moretti and *R. rostratus* DC., all of which are found wild in the Mediterranean region. The Japanese types are thought to have been derived from *R. sativus* f. *raphanistroides* Makino syn. *R. raphanistroides* Sinsk., which occurs wild in the coastal regions of Japan. The Indian group of radishes including the rat-tail radish are also similarly believed to have evolved in the area of their present distribution, though their presumed ancestors have been lost (Bailey & Bailey, 614: Bailey, 1947, III, 2896; Schulz in Das Pflanzenreich, Heft 70, 1959, 194; Mansfeld, 96; Sinskaia, loc. cit.).

R. sativus exhibits a wide range of forms with regard to size, shape and colour of the roots, time required to reach maturity after planting and the keeping and edible quality of root. A large number of species and varietal crosses, as well as some intergeneric crosses with the closely allied genus *Brassica*, have been effected. All the species of *Raphanus* including *R. sativus* have 2n = 18 chromosomes. The commercial types of radish are said to be largely self-incompatible. *R. sativus* is said to cross easily with *R. raphanistrum*. In the case of the intergeneric cross with *Brassica oleracea* (the Cabbage and the Brussels Sprout), the cross is successful with the radish as the female parent but when it is used as the male parent the cross is unsuccessful. The other species of *Brassica* with which the radish has been crossed are *B. carinata* (Abyssinian mustard), *B. chinensis* (Chinese cabbage) and *B. rapa* (Turnip), and the hybrids are characterized by varying degrees of sterility [Darlington & Wylie, 47; Poole, *Yearb. Agric., U.S. Dep. Agric.*, 1937, 304, 317; Watts, *J. hort. Sci.*, 1960, **35**, 22; Hector, II, 613–16; Subrahmanyam, *Curr. Sci.*, 1954, **23**, 60; Richharia, ibid., 1936–37, **5**, 228; *J. Indian bot. Soc.*, 1937, **16**, 137; *J. Genet.*, 1937, **34**, 19; Morris & Richharia, ibid., 1937, **34**, 275; Howard, ibid., 1938, **36**, 239; Mizushima, *Tohoku J. agric. Res.*, 1950, **1**(1)].

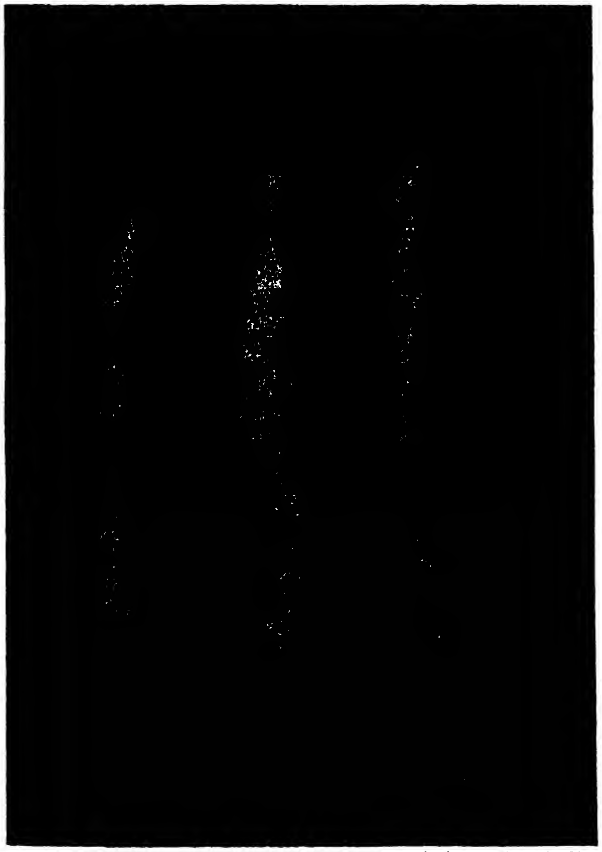
A large number of types of radish, indigenous as well as introduced, are found under cultivation in the different areas of the country. The indigenous types usually cultivated are white with a conical shape, attaining 25–40 cm. in length, and are said to be generally more pungent than the introduced European types. Amongst the latter, there are red, purple or scarlet types, but they are not so common as the white long-rooted types. A type cultivated in and around Jaunpur in Uttar Pradesh and known as *Newari* or *Jaunpuri mooli* reaches an enormous size with a length of up to 75–90 cm. and a girth of 50–60 cm., and may weigh up to 5–15 kg. or even more. It is said that this giant radish can be successfully grown only under irrigation with the kind of brackish water found in that area and when cultivated elsewhere it does not attain this size. *Baramasi* is

I.C.A.R., New Delhi

FIG. 138—RAPHANUS SATIVUS (JAUNPURI)

I.A.R.I., New Delhi

RAPHANUS SATIVUS—DIFFERENT TYPES



I.C.A.R., New Delhi

FIG. 139—RAPHANUS SATIVUS (JAPANESE WHITE)

another indigenous type that can be grown throughout the year. *Pusa Desi White* is an improved indigenous type. *Japanese White, 40 days, China Rose, Chinese Pink,* and *Miyashige* are some of the introduced Asiatic types, while *French Breakfast, Purple Top White, Scarlet Globe, White Icicle, Rapid Red Round, Wood's Long Frame* and *Pariser* are some of the introduced European types [Mishra, *Kanpur agric. Coll. J.*, 1956, **15**, 67; Juneja & Upadhyaya, *Himachal Hort.*, 1962, **3**, 239; Singh, *Indian Fmg, N.S.*, 1963–64, **13**(1), 21; Singh *et al.*, *Indian J. Hort.*, 1960, **17**, 38; Singh & Prasad, *Indian Hort.*, 1966, **10**(4), 15].

Cultivation—The radish is cultivated in all parts of the country from the coastal plains to the Himalayan ranges up to altitudes of *c.* 3,000 m. or even more. In general, the radish is a cool season crop, though there are said to be some indigenous types that can be grown throughout the year. There are certain regions in the country, for example, South India, where radish is cultivated all round the year. The main season for sowing in the northern plains for indigenous types is from August to January and for European types from September to March. In the hills they are sown from March to July. The best sowing periods in South India are from April to June in the hills, and October to December in the plains (Purewal, *Farm Bull.*, No. 36, 1957, 24; Handbook of Agriculture, 347; Milne *et al.*, 86).

Though the radish thrives in all kinds of soils, a rich friable sandy loam is preferred, as heavy soils are likely to yield ill-shaped roots. Cool moist soils such as silt and silt loams give better results for the summer crop. The soil should be well manured with *c.* 40 tonnes of well-rotted farmyard manure per hectare. In addition, nitrate of soda or ammonium sulphate should be applied as top dressing to stimulate growth and ensure tender roots (Purewal, loc. cit.; Thapar, 186; Thompson & Kelly, 341).

Radish seeds count *c.* 70–100 per gram and *c.* 7–12 kg. of seed is required to plant a hectare depending upon the type of radish and distance of planting. Sowing in nursery beds and transplanting only healthy and strong seedlings, when they have put out 2 or 3 leaves, is recommended to obtain a uniform crop. Sifting of seeds before planting so as to separate the larger seeds for sowing is also recommended. Seed is sown on ridges *c.* 50 cm. apart and 25 cm. high to supply about 40–60 plants per metre of the row. The seeds germinate in 3–4 days. Irrigation is given immediately after sowing and is repeated every 5–10 days depending on the season. As the plants grow they are thinned out to *c.* 10 cm. or more from each other. One or two weedings are given in the growing season, but as the crop grows fast weeds do not cause much trouble (Bailey, 1947, III, 2896; Purewal, loc. cit.).

Presowing treatment of seeds with 20 p.p.m. NAA is said to give an increased yield of edible roots. Treatment of seeds with 10 p.p.m. of gibberellic acid for 6 hours before sowing increased the length, weight and ultimate yield of roots. In one trial, radish is said to have had a deleterious effect on the succeeding crop of maize (Singh & Dohare, *Punjab hort. J.*, 1964, **4**, 160; Srivastava, *Allahabad Fmr*, 1965, **39**, 249; Annett, *Agric. J. India*, 1917, **12**, 151).

Diseases and Pests—Radish is subject to very few diseases and pests in this country. Root rot caused by *Pythium aphanidermatum* (Edson) Fitzpatrick is reported to attack seedlings. The cabbage black ring spot virus belonging to turnip virus 1 group is reported from Uttar Pradesh. *Aphis gossypiae* Glover,

Myzus persicae (Sulz.), and *Brevicoryne brassicae* Linn., are reported to be the vectors (Mahmud, *Allahabad Fmr*, 1950, **24,** 80; Bhargava & Joshi, *Vijnan Parishad Anusandhan Patrika*, 1959, **2,** 211; Joshi & Bhargava, *Proc. nat. Acad. Sci. India*, 1964, **34B,** 225).

The mustard saw-fly, *Athalia proxima* Klug., which is a pest of the nurseries of cruciferous plants is said to cause severe damage sometimes. Hand-picking of larvae where the area involved is small, or spraying with lead arsenate or dusting with BHC are recommended. The mustard aphis, *Siphocoryne indobrassicae* Das, sometimes attacks radish and other cruciferous crops. Spraying with nicotine sulphate or dusting with Hexamar BHC or Gammexane are recommended [Narayanan, *Indian Fmg, N.S.*, 1953–54, **3**(8), 9; Wesley, *Allahabad Fmr*, 1958, **32,** 5].

Harvesting and Yield—The radish comes to harvest within 30–50 days of sowing and should be pulled out when the root reaches edible size and is still tender and crisp, as otherwise with delay it soon becomes tough, pithy, hollow and unpalatable. Treatment of 6 week-old radish plants with a 0.10 per cent aqueous spray of maleic hydrazide is said to prevent bolting, and the roots remain turgid and edible for a longer period after harvesting, as compared to untreated plants; they are also sweeter and less pungent. Yields of *c.* 7,500 kg./ha. in the case of introduced European types and *c.* 15,000–20,000 kg./ha. in the case of indigenous types are said to be obtained; in Jaunpur (Uttar Pradesh) yields as much as *c.* 45,000 kg./ha. are obtained in the winter crop (Milne *et al.*, 86; Purewal, loc. cit.; Mishra, loc. cit.).

The radishes can be stored at room temperature for 3–4 days during winter in North India without impairing their quality. Under cold storage they can be kept for over 2 months at 0° at an R.H. of 90–95 per cent (Purewal, loc. cit.).

Seed production—While seeds of indigenous types of radish as well as some introduced types can be successfully produced in the plains, the temperature requirements for production of seed of most types, introduced from temperate countries, are more specific and their seed can successfully be produced only in some hill areas where temperatures remain around 5° for a continuous stretch of 1½ to 2 months. Seeds of such introduced types are now being successfully produced in Katrain in the Kulu valley, Himachal Pradesh. Some of these types produce a good crop of seed if seed is planted in autumn and the plants allowed to overwinter, while in the case of others the crop for seed can be sown in spring and harvested in autumn. The crop can be left *in situ* in the field to flower and set seed ("seed to seed" method) or it may be replanted after selection of roots ("root to seed" method) which gives an opportunity to reject underdeveloped, ill-formed or off-type roots. In the latter case the roots are sometimes pruned before being replanted, and trials are said to have shown that roots where one-fourth of the length is pruned yield more and heavier seed than pruning entire roots or major portion of it. Both nitrogen and phosphorus are very important for the seed crop, but too much nitrogen may delay seed maturity. The plants are cross pollinated by insects—chiefly bees—and where different types of radish are to be grown for seed, it is desirable to allow a distance of about 0.5 km. between each type, but this distance should be as much as 1.5 km. where mother seed is being produced. For hybrid seed production, self incompatible inbred lines are grown interspaced with one another. The pods do not shatter and the drier they are harvested the easier it is to thresh them, as threshing of radish pods is often difficult. Some farmers are reported to use rubber-wheeled tractors for this purpose. The yield of seeds obtained in Kulu

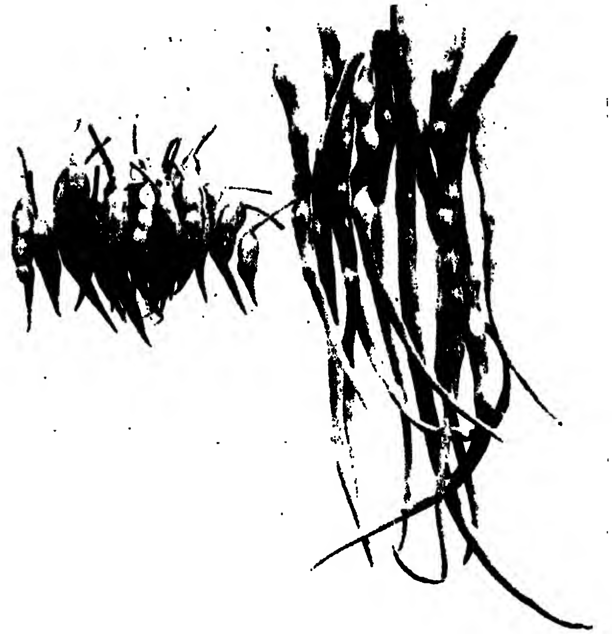


FIG. 140—RAPHANUS SATIVUS—FRUITS

valley ranges from 320 to 600 kg./ha. depending upon the type and time of sowing. Seeds stored well in temperate regions remain good up to 4 years [Shesi & Padda, *Punjab hort. J.*, 1964, **4**, 137; Tomar & Date, *Gardening*, 1960, **2**(8), 14; Singh *et al.*, *Indian J. Hort.*, 1960, **17**, 38; Singh & Prasad, *Indian Hort.*, 1966, **10**(4), 15; Jauhari & Purandare, *Sci. & Cult.*, 1959-60, **25**, 256; Agricultural and Horticultural Seeds, 417–20].

Utilization—The radish is eaten raw as salad or cooked as vegetable; it is much relished for its pungent flavour and is considered an appetizer. The leaves are also boiled and eaten. Sometimes due to climatic or other conditions the crop is likely to be poor and produces very small or inferior roots; then it is allowed to flower and produce pods, which are commonly known as *mungra*. These are also eaten raw or cooked as vegetable. The radish has also been tried successfully as a fodder crop in some countries like the U.K., and South Africa. In the latter country the giant radish of Japan has been grown for this purpose and yields of more than 60 tonnes/ha. of roots and 12–25 tonnes/ha. of leaves have been obtained. It is said to be relished by all animals and the characteristic pungent smell of the root is not imparted to the milk. In feeding value, radish is said to compare very favourably with any other root crop (*Agriculture, Lond.*, 1964, **71**, 568; Kolbe & Voss, *Fmg in S. Afr.*, 1952, **27**, 235).

Radish is credited with refreshing and depurative properties. Radish preparations are useful in liver and gall bladder troubles. In homoeopathy they are used for neuralgic headaches, sleeplessness and chronic diarrhoea. Roots, leaves, flowers and pods are active against Gram-positive bacteria. The roots are said to be useful in urinary complaints, piles and in gastrodynia. A salt extracted from roots dried and burnt to white ash, is said to be used in stomach troubles. The juice of fresh leaves is used as diuretic and laxative. The seeds are said to be peptic, expectorant, diuretic and carminative (Nutritive and Therapeutic Value of Fruit and Vegetables, 144; Hoppe, 762; *Chem. Abstr.*, 1962, **57**, 964; Kirt. & Basu, I, 178; Mishra, loc. cit.; Steinmetz, II, 377).

Composition—Chemical composition of white and pink radishes is given in Table 1. Radish is a good source of ascorbic acid (15-40 mg./100 g.) and supplies a variety of mineral salts. Trace elements in radish include aluminium, barium, lithium, manganese, silicon, titanium, fluorine and iodine (up to 18 μg./100 g.) Pink-skinned radish is generally richer in ascorbic acid than the white-skinned one. In the former, the vitamin is more concentrated in the skin in association with the pigment than in the flesh. Salad made from coloured upper skin together with young radish leaves could serve as an excellent source of ascorbic acid. There is an appreciable loss of ascorbic acid during storage, cooking, or drying of radish (Thorpe, X, 444; *Chem. Abstr.*, 1947, **41**, 5649; Garber, *Qualit. Plant. Mat. Veg.*, 1962-63, **9**, 33; Iodine Content of Foods, 85; Qudrat-i-Khuda & Sharif, *Pakist. J. sci. industr. Res.*, 1959, **2**, 279; Kibe & Mahapatra, *Poona agric. Coll. Mag.*, 1965, **55**, 5; Lal Singh *et al.*, *Indian J. agric. Sci.*, 1951, **21**, 137).

Radish contains glucose as the major sugar and smaller quantities of fructose and sucrose. Pectin (0.3%, as calcium pectate) and pentosans are also reported, while starch is absent. Organic acids detected include *p*-coumaric, caffeic, ferulic, phenyl pyruvic, gentistic, and *p*-hydroxybenzoic acids; the total acid content is less in white radish than in red radish. Non-protein nitrogen accounts for about 40 per cent of total nitrogen; the free amino acids identified include most of the essential amino acids (*Chem.*

TABLE 1—CHEMICAL COMPOSITION OF RADISH*

	Radish roots (White)[1]	Radish roots (Pink)[2]	Radish tops	Radish fruits
Edible matter, %	99.0	98.0	..	88.0
Moisture, %	94.4	90.8	90.3	90.5
Protein, %	0.7	0.6	2.7	2.3
Fat, %	0.1	0.3	0.6	0.3
Fibre, %	0.8	0.6	0.9	1.4
Other carbohydrates, %	3.4	6.8	3.4	4.7
Minerals, %	0.6	0.9	2.1	0.8
Calcium, mg./100 g.	50.0	50.0	310	80
Phosphorus, mg./100 g.	22.0 (phytin, 0)	20.0 (phytin, 13)	60	100
Iron, mg./100 g.	0.4	0.5	16.1	2.8
Vitamin A, I.U./100 g.	5.0	5.0	18,660	50
Thiamine, mg./100 g.	0.06	0.06	0.03	0.07
Riboflavin, mg./100 g.	0.02	0.02	0.16	0.05
Nicotinic acid, mg./100 g.	0.5	0.4	0.3	0.2
Vitamin C, mg./100 g.	15.0	17.0	103	69

* Nutritive Value of Indian Foods, 59, 57, 73, 93, 95, 109, 125, 127, 137.

[1] Also contains: sodium, 33; potassium, 138; choline, 63; and oxalic acid, 9 mg./100 g.; [2] Also contains: magnesium, 9; sodium, 63.5; potassium, 10; copper, 0.2; sulphur, 31; chlorine, 11; and oxalic acid, 20 mg./100 g.

Abstr., 1966, **65**, 10959; Thorpe, X, 443; Trehan & Ahmad, *J. sci. industr. Res.*, 1947, **6B**, 16; Laxminarayan Rao *et al.*, ibid., 1956, **15C**, 39; Kulkarni & Sohonie, *Indian J. med. Res.*, 1956, **44**, 511).

The characteristic pungent flavour of radish has been attributed to the presence of volatile *iso*thiocyanates (mustard oils). A volatile oil distilled from white radish was reported to contain butyl crotonyl *iso*thiocyanate sulphide, with a typical radish odour, as the chief constituent. Methyl mercaptan has been reported to be responsible for the disagreeable odour of radish oil. According to a recent investigation, *trans*-4-methyl-thiobutenyl *iso*thiocyanate is the pungent principle of radish. The *iso*thiocyanate occurs in the form of a glucoside, and is released when the glucoside is hydrolysed by the action of an enzyme also present in radish (Guenther, VI, 62; Gildemeister & Hoffmann, V, 176; *Chem. Abstr.*, 1966, **65**, 7041).

Coloured radishes contain anthocyanin pigments which occur naturally acylated either with ferulic or with *p*-coumaric acid. Red-skinned radish yields cyanidin-5-glucoside-3-sophoroside, whereas scarlet-skinned radish yields the corresponding pelargonidin diglycoside. The purple-skinned radish from Kangra (Himachal Pradesh) was found to contain a cyanidin diglycoside. Catechol is reported in a red type. Flavonols are present in radishes in minute quantities (Harborne, *Phytochemistry*, 1963, **2**, 85; Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B**, 211; Jacobs, II, 1297; *Chem. Abstr.*, 1959, **53**, 9389).

The enzymes present in radish are phosphatase, catalase, sucrase, amylase, alcohol dehydrogenase and pyruvic carboxylase. Radish contains a thermostable antithiamine factor and S-methyl-L-cysteine sulfoxide designated as methiin (m.p. 173–74°). Steroidal sapogenins are also reported (Jacobs, II, 1297; *Chem. Abstr.*, 1964, **61**, 6276, 15093; Anzaldo *et al.*, *Philipp. J. Sci.*, 1958, **87**, 191).

Leaves—The leafy tops of radish are sometimes eaten as vegetable or fed to animals. They are highly nutritious, being a good source of vitamins and minerals (Table 1). They are particularly rich in calcium, iron, and ascorbic acid, and are also considered to be one of the richest sources of vitamin A among the leafy vegetables. The leaves can constitute a good supplement to diets consisting mainly of rice. Oxalic acid content of the leaves is reported to be high (total oxalates, 0.68%; soluble oxalates, 0.39%) and as such may affect the calcium availability to the system. It has, however, been observed that a vegetable though rich in both calcium and oxalates, could serve as a fairly good source of calcium if consumed with rice; phytin in rice appears to help calcification. The leaves have a high strontium content (82.9 mg./100 g. on dry basis). They also contain iodine (19.8 μg./100 g.) and ascorbigen [Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29**(2 & 3), 151; Theophilus & Arulanantham, *Indian J. med. Res.*, 1949, **37**, 29; Sadana & Ahmad, *J. sci. industr. Res.*, 1947, **6B**, 47; Anantha Samy *et al.*, *Curr. Sci.*, 1960, **29**, 133; Iengar & Rau, *Ann. Biochem.*, 1952, **12**, 41; Chauhan & Sarkar, *Indian J. Chem.*, 1964, **2**, 175; Iodine Content of Foods, 85; *Chem. Abstr.*, 1959, **53**, 13294].

The leaves of radish are a good source for the extraction of protein on a commercial scale. The leaf protein has a biological value of 76.6, and digestibility co-efficient of 73.5 per cent. It can be used to supplement protein deficiency. Twenty-two amino acids have been identified in the non-protein nitrogenous fraction (Terra, *Commun. R. trop. Inst., Amst.*, No. 54e, 1966, 70; *Rep. Dep. Nutr. Govt. Bombay*, 1957, 28; Nazir & Shah, *Pakist. J. sci. industr. Res.*, 1966, **9**, 235; *Chem. Abstr.*, 1957, **51**, 18137).

The leaves yield an essential oil (0.002%) containing 2-hexen-1-al (leaf aldehyde), 3-hexen-1-ol (leaf alcohol), and small quantities of *n*- and *iso*butyraldehyde and *iso*valeraldehyde. Flavone compounds are also present in the leaves (Guenther, VI, 62; *Chem. Abstr.*, 1959, **53**, 9389).

Seeds—Radish seeds contain glycosidically bound mustard oils of which allyl, methyl, and *iso*propyl *iso*thiocyanates, and sulphoraphene have been identified in different varieties; 4-methylsulfinyl-3-butenyl cyanide, the corresponding nitrile of sulphoraphene and cleavage product of its glucoside, has also been isolated. Sulphoraphene exhibits antibacterial activity against *Streptococcus*, *Pyococcus*, *Pneumococcus* and *Escherichia coli*. It also has blastokolic property, i.e. it inhibits the germination of seeds. Another sulphur-containing oil, named raphanin, has been separated from the aqueous extract of the seeds. It is active against several Gram-positive and Gram-negative bacteria, and possesses blastokolic effect. It has been suggested that raphanin is identical to sulphoraphene. The seeds are also reported to contain a broad-spectrum antibiotic, named machrolysin, specific against *Mycobacterium tuberculosis* (Kjaer *et al.*, *Acta chem. scand.*, 1953, **7**, 1276; Schmid & Karrer, *Helv. chim. acta*, 1948, **31**, 1017, 1087; Ivanovics &

Horvath, *Nature, Lond.*, 1947, **160,** 297 : *Chem. Abstr.*, 1950, **44,** 5538, 8063 ; 1956, **50,** 11619).

Radish seeds are a potential source of a non-drying fatty oil (av. yield, 30–50%) suitable for soap making, illuminating and edible purposes. The hydrogenated oil is reported to be used in the manufacture of crayon in Japan. A sample of seeds on extraction with petroleum ether yielded 46.5 per cent of oil with the following characteristics: sp. gr.$^{30°}$, 0.9173 ; $n^{30°}$, 1.4704 ; acid val., 0.9 ; acet. val., 2.8 ; sap. val., 178.9 ; iod. val. (Hanus), 103.1 ; thiocyanogen val., 79.0 ; R.M. val., 0.6 ; Hehner val., 94.2% ; and unsapon. matter, 0.24% ; fatty acid composition: palmitic, 1.3 ; stearic, 1.4 ; arachidic, 3.0 ; behenic, 3.4 ; erucic, 22.0 ; oleic, 60.8 ; linoleic, 4.5 ; and linolenic, 3.6%. In another study, radish seeds from Kannauj (Uttar Pradesh), on petroleum ether extraction, gave 32.5 per cent oil (iod. val., 93.1) with the following fatty acid composition: palmitic, 3.9 ; stearic, 2.1 ; behenic, 2.3 ; hexadecenoic, 23.5 ; oleic, 11.1 ; linoleic, 12.3 ; dicosenoic, 19.8 ; and erucic, 25.0%. The unsaponifiable matter contains triacontane, sterols, a ketone, traces of a flavonoid, and a weak base. The seeds have a high tocopherol content and possess strong antioxidant activity [Eckey, 446 : Prakash *et al.*, *J. Oil Technol. Ass. India*, 1955, **11,** 79 : *Chem. Abstr.*, 1952, **46,** 8294 ; Singh & Kumar, *Proc. Indian Acad. Sci.*, 1948, **27A,** 156 : *Oils & Oilseeds J.*, 1957–58, **10**(11), 11 : Sosa & Duperson, *C.R. Acad. Sci., Paris*, 1952, **235,** 82 : *Chem. Abstr.*, 1964, **61,** 7363 ; 1958, **52,** 7739].

The seed cake or meal is rich in proteins and appears to be suitable for use as manure and after removal of *iso*thiocyanates as a feedstuff. A sample of solvent-extracted seed meal from the United States yielded 52.5 per cent protein (on dry basis), and had the following amino acid composition (mg./g.N): lysine, 300 ; methionine, 109 ; leucine, 387 ; *iso*leucine, 220 ; phenylalanine, 228 ; threonine, 235 ; valine, 293 ; histidine, 171 ; and arginine, 439. The seed meal has a high methionine content ; *iso*leucine is the limiting amino acid. The nutritive quality of the protein indicates that the seed meal is a satisfactory food for growth and maintenance (Prakash *et al.*, loc. cit. ; Miller *et al.*, *J. agric. Fd Chem.*, 1962, **10,** 426).

RAPHIA Beauv. (*Palmae*)

A genus of large palms with about 20 species, found in tropical Africa and America. Three species have been introduced into India and are found cultivated. Raphia palms are valued for the fibre obtained from their leaves ; they also yield a wine.

R. farinifera Hylander syn. *R. pedunculata* Beauv. ; *R. ruffia* Mart. RAFFIA

Blatter, 248, Pl. XLVI.

A short-stemmed, robust feather palm, native of Malagasy, introduced and grown in India. Stem up to 9 m. high and often about 1 m. in diameter ; leaves about 15 m. in length : spadix very large, from 2.1 to 3.3 m. long ; fruits 2.5–5.0 cm. long, more or less turbinate or globose-ovate, slightly depressed at the apex ; seed obovate, rotundate at apex.

Raffia palm, in its native habitat, is often found growing in low-lying areas and lake levels, though it can grow up to an altitude of 1,500 m. (Williams, 430 ; Willis, 557).

The palm yields a very good commercial fibre (RAFFIA) obtained from strips of the lower epidermis and petioles of the leaves. The fibre is obtained by retting. Good quality fibre is pale in colour and about 120 cm. long. It is used for binding, weaving mats, hoods, bags, ceremonial aprons, hats, curtains, etc. It is also used for making fancy articles as it takes dyes (Watt & Breyer-Brandwijk, 815 ; Irvine, 1961, 783 ; Burkill, II, 1868 ; Williamson, 104 ; Thorpe, IV, 165).

The lower surface of the tender leaves is glaucous and covered with a whitish layer of wax (RAPHIA WAX). The yield of refined wax is about 0.75 per cent based on the weight of the leaves. Raphia wax (m.p. 82–83° ; iod. val., 7.7–10.7) is yellow to dark brown in colour, somewhat harder and more brittle than beeswax and resembles carnauba wax in its physical properties. It probably consists chiefly of high molecular weight alcohols (C_{28-32}) and hydrocarbons. The wax is used in boot and floor polishes and candles (Warth, 183–84 ; Thorpe, XI, 939).

The fruit pulp yields 24 per cent of a brown fatty oil (m.p. 17–18° ; sap. val., 197) containing a high proportion of saturated acids (stearic and palmitic in the ratio of 3 : 1). The seeds yield 1 per cent of a thick brown oil. The oils can be used for edible purposes after refining or for making soaps and stearin (Mensier, 486–87).

The solid, very strong, midrib of the leaves is put to a variety of uses, for roof and tent poles and for making doors and furniture. The midrib of the leaflets is used to make the frame-work of fish weirs and of baskets (Dalziel, 512 ; Williamson, 104 ; Williams, 430).

In Malagasy, the shells of the fruits are made into receptacles for small articles and also into snuff-boxes, cigarette-holders and buttons (Burkill, II, 1868).

R. hookeri Mann & Wendl. WINE PALM

Russell, *Kew Bull.*, 1965, 181.

A tall palm, native of West tropical Africa, introduced and grown in Indian gardens. Trunk up to 10 m. in height and 30 cm. in thickness, clothed in the upper part with blackish fibres, derived from the breakdown of leaf bases; stem single, occasionally with 1–4 suckers, but a dense clump is not formed; leaves 12 m. long, leaf segments rigid, 1.5 m. long, 4 cm. wide, waxy and glaucous below; spadices 2.5 m. long, compressed cylindrical with crowded branches; fruits 6–12 cm. long and 4–5 cm. wide with a stout beak 1.0–1.5 cm. long.

R. hookeri is the main source of a wine known as Bourdon, though until recently *R. vinifera* was considered to be the wine-yielding species. The fresh sap obtained by cutting and tapping the inflorescence is allowed to ferment for 2–3 days. Fresh wine tastes like ginger-beer. A sample of wine preserved with thymol and examined two years after vinification contained: dry extr., 7.94; total N, 0.86; amide N, 0.13; sugars, nil; mineral substances, 1.65; total acidity (as sulphuric acid), 0.47; acetic acid, 0.41; esters (as ethyl acetate), 0.07; and ethyl alcohol, 3.21%. An arrack is prepared by distilling the wine (Dalziel, 511–12; *Chem. Abstr.*, 1963, **59**, 1052; 1952, **46**, 6319; Hill, 491).

Besides wine, the palm also yields a fibre, the PIASSAVA, which is useful for stiff brooms. In Nigeria, there is an important mat-making and basket-weaving industry based on this fibre. The fibre is used for cordage, which is very strong and stands up well to moisture and sun (Russell, *Kew Bull.*, 1965, 181).

R. vinifera Beauv. BAMBOO PALM, PHAROAH'S PALM

Blatter, 252, Pl. XLVII.

A large handsome palm found abundantly in the tidal bays and creeks on the west coast of Africa, introduced and grown in Indian gardens. Stem short; leaves rising almost vertically from the stem forming a magnificent plume; spadices very large, compoundly branched and drooping; spikelets slightly arcuate, much compressed; fruits cylindrical-ellipsoidal.

A fibre known as WEST AFRICAN PIASSAVA or LAGOS BASS is obtained from the sheathing leaf bases of this palm. The leaf stalks from mature leaves are split longitudinally in thin strips from the sides, back, front and middle. The side strips yield the best fibre, while the middle ones have weak and straw-like fibres. The strips are bundled and retted in water for 6–12 weeks or more and beaten to remove pith and extraneous matter and then hackled. After hackling, the fibre is hand-picked, dried in the shade and bundled. Piassava is light to reddish brown depending upon the water used for retting and is 60–150 cm. long (length and diam. of ultimate fibre, 0.35–1.7 mm. and 9.0–26.5μ respectively). The fibre is used for brooms, roller sweeping brushes and in brushes used to remove air bubbles from steel castings. Cords, fishing tackles and snares for game are also made from the fibre. A cheap upholstery material called Piassava tow resembling coir and used as a substitute for it, is got from the waste matter and pith extracted in cleaning the fibres. A wax is also extracted from the leaves (Kirby, 403–04; Burkill, II, 1868; Dalziel, 511).

The petiole and midrib of the leaves are used like bamboo, for roofing poles, for canoes and as carrying poles. They are used to make small furniture (Dalziel, 511; Russell, *Kew Bull.*, 1965, 181).

The single nut has a sculptured surface and between it and the scaly husk is a yellow oily pulp eaten as food or used as a bitter flavour. It is also used medicinally as a stomachic and laxative, and as a liniment. By treating the nuts with boiling water a yellow fat called Raphia butter is obtained, which is of good taste when fresh. In parts of West Africa, it is used in lighting, as a lubricant, pomade and also in cooking. The kernels are roasted and eaten in Gabon. They are also used as vegetable ivory, to make buttons and ornaments. The terminal bud of the palm is eaten as a vegetable (Macmillan, 292; Watt & Breyer-Brandwijk, 815; Dalziel, 512).

RARE EARTHS

The rare earth metals are a group of 15 elements having atomic number from 57 to 71, i.e. lanthanum through lutetium; however, yttrium (atomic number, 39) is generally included on account of its similar properties. The members of the group, also known as lanthanons, are so similar in chemical properties that they have been generally considered as occupying the position of a single element in the periodic system. Except for promethium, the rare earth metals always occur together and in combined form. Until recently, the rare earths were obtained mainly as a by-product of thorium and uranium extraction from monazite; they are now also produced as primary products for industry from bastnasite. The rare earth metals and their salts are used chiefly in ferrous and non-ferrous metallurgy, glass and ceramics, arc carbons,

and phosphors for television. With increasing availability, they are being intensively studied and great diversification in their utilization is being effected.

The rare earth metals are found as mixtures in a number of minerals which commonly occur in pegmatitic segregations or as subordinate accessory minerals in granitic or other igneous rocks. Monazite and bastnasite are the principal source minerals of rare earth metals; bastnasite is not found in India.

Monazite, a phosphatic mineral of lanthanon and thorium metals [(Ce, La, Y, Th) (PO_4); sp. gr., 4.9–5.3; H., 5.0–5.5] is found as placer deposit in the coastal sands, concentrated by natural flotation process from the eroded material of drained rocks. Massive deposits of monazite are also known. The mineral is red, brown, or yellow in colour. Among the other minerals of Indian occurrence are aeschynite, allanite (or orthite), annerodite, euxenite, fergusonite, gadolinite, pyrochlore, samarskite, sipylite, tscheffkinite and xenotime. Bastnasite, a fluocarbonate of lanthanons [(Ce, La, Di) (CO_3) F; sp. gr., 4.94; H., 4.5] occurs in massive vein deposits. It contains little thorium but larger amount of rare earth oxides as compared to monazite. Table 1 gives the rare earth constituents of monazite and bastnasite.

TABLE 1—RARE EARTH CONSTITUENTS OF MONAZITE AND BASTNASITE (%)*

Rare earths (oxides)	Monazite India	Monazite Brazil	Monazite U.S.A.	Bastnasite U.S.A.
Lanthanum	15.7	62.12 (La–Nd)	17.0	24.6
Cerium	30.6		29.9	47.1
Praseodymium	2.9		3.9	4.4
Neodymium	10.5		11.0	12.6
Samarium	0.7 (Sm–Tb)		1.3	0.7
Europium			0.001	
Gadolinium			0.5	
Terbium				
Dysprosium	0.1 (Dy–Lu)	0.80 (Dy–Lu)	0.1 (Dy–Lu)	0.5 (Dy–Lu)
Holmium				
Erbium				
Thulium				
Ytterbium				
Lutetium				
Yttrium	0.4		0.9	
Thorium	8.1	6.06	3.5	0.1

* Johnstone & Johnstone, 583; Kremers in Hampel, 394.

The principal producers of monazite are India and Brazil, and that of bastnasite is the U.S.A. Monazite is also produced in Australia, Malaysia, Indonesia, Malagasy, Ceylon, the Union of South Africa, and a few other countries. India contributes a major fraction of world output of monazite and supplies nearly one-third of the world's requirement of rare earths [Spedding in Spedding & Daane, 3; Kremers in Hampel, 393; *Sciences*, 1967, **6**(9), 15; Eyring, 416; Wadia, *East. Met. Rev.*, 1958–59, **11**, 125; Sharma, *Trans. Indian ceram. Soc.*, 1944, **3**, 97; *Chem. Engng World*, 1968, **3**(2), 65; Mertie in Gillson *et al.*, 623–25; Johnstone & Johnstone, 582; Kirk & Othmer, XI, 505; Dana, 526, 700].

Distribution—Monazite is the most important commercial mineral of rare earth metals in India. The largest monazite deposits occur in Kerala, Madras and Bihar. For distribution, *see* **Monazite** (Wlth India—Raw Materials, VI, 413).

Several other minerals containing rare earth metals have been found in the pegmatite-veins of crystalline rocks in various parts of India, but they are commercially unimportant. Aeschynite has been recorded at Erania taluk in Kerala. Allanite occurs at several localities in Hazaribagh district (Bihar), and in South Arcot (Madras); it has also been reported from Bhilwara and Pali districts of Rajasthan. Annerodite and fergusonite occur in Ceylon, and because more or less similar geological conditions prevail in the adjacent parts of India, these minerals are likely to be found in South India. Euxenite has been recorded at Erania taluk in Kerala; and gadolinite at Hosainpura, Banas Kantha in Gujarat. A mineral related to pyrochlore has been reported from Vayampati in Tiruchchirappalli, Madras.

Samarskite has been reported from the mica mines near Griddalur and Parlapalli in Nellore district, Andhra Pradesh. Sporadic occurrences of this mineral have also been recorded at Borara and Mundoti in Jaipur district, Rajasthan. Sipylite has been reported from Sankara and Razulapad in Nellore. Tscheffkinite has been found near Kanjamalai Hill in Salem district, Madras. Sporadic occurrence of xenotime has been reported from near Ajmer in Rajasthan; and a mineral related to xenotime has been reported from Aru Buru near Kanyaluka in Singhbhum district, Bihar (Chatterjee, 422–25, 451; Coggin Brown & Dey, 237–38, 286).

Mining and Treatment—Monazite is mined from the coastal deposits at Chavara in Kerala, and Manavalakurichi in Madras. The heavy black sand is

scraped from the surface with spades, sun dried and sent to the beneficiation plants for concentration and separation of monazite from other constituent minerals. The concentrated fraction, enriched to a product containing 97–99 per cent monazite, is despatched to *Indian Rare Earths Ltd*, Alwaye, for the recovery of rare earths, thorium and uranium. The rare earth metals are recovered mainly in the form of mixed chloride. The plant also produces mixed rare earth fluoride, mixed rare earth carbonate, crude cerium hydroxide and cerium nitrate. Necessary steps towards the separation of individual rare earths are in progress. For details of extraction *see* **Rare Earths Industry** (Wlth India—Industrial Products, pt VII).

Properties and Uses -Rare earth metals have a silvery-grey lustre, but tarnish quickly in air. They are soft and malleable, and their hardness increases with the atomic number. They have good heat and fair electrical conductivity. They are active reducing agents. The rare earth metals combine with most non-metals and form alloys with nearly all metals. They are used as mixtures, compounds and also as individual metals. The most important mixture of rare earth metals containing about 50 per cent cerium is known as misch metal. Lanthanum-enriched misch metal and ferro-cerium are also commercially important (Kirk & Othmer, XI, 513–15; Kremers in Hampel, 401–07, 414).

Rare earth metals and their salts find major application in three industries, viz. metallurgy, glass and ceramics, and carbon arc lighting. An increasing use for rare earth metals is in special types of stainless steels and other ferrous and non-ferrous alloys. An alloy of misch metal with iron (18–30%) is extensively used in the manufacture of lighter flints. In magnesium alloys, misch metal increases their high temperature strength so that such alloys are particularly useful in jet engine castings and air frame structures. Rare earth metals find use also in the preparation of cast iron welding rods, and as "getters" in electronic tubes (Kremers in Hampel, 410–14; Eyring, 423–40).

Salts of rare earth metals are used for decolourizing glass and as ultraviolet and infrared light absorbers, e.g. in optical glass filters, spectacles and glass blowers' goggles. They are extensively used in glass polishing particularly for mirrors and lenses. Some of the salts are used to a small extent as colouring agents in decorative glass. Rare earths also find use in porcelain enamels, glazes, ceramic coatings and high grade refractories (Eyring, 441–46; Kirk & Othmer, XI, 519–20).

Rare earth fluorides and oxides are largely used in the cores of carbons for arc lighting in motion picture projectors and search lights. Rare earth oxides, particularly those of europium and yttrium, are being widely used in the manufacture of TV-phosphors. Other uses of rare earths are in the field of electronics, nucleonics, as catalysts in petroleum cracking and in a host of other industries [Eyring, 446–70; Kirk & Othmer, XI, 519; *Sciences*, 1967, **6**(9), 15].

Production and Trade— A provisional estimate by the Atomic Energy Department places the total reserves of monazite in India at over 5 million tonnes, capable of yielding well over 400,000 tonnes of combined rare earths. Production of monazite in India, over the years 1962–66, varied from about 2,000 to 2,500 tonnes per annum. *Indian Rare Earths Ltd*, presently treats about 3,600 tonnes of monazite per year, mainly for the production of thorium, rare earths being recovered as by-product. The production of monazite is controlled by the Department of Atomic Energy (Meher Wadia, 166–67; *Chem. Age India*, 1965, **16**, 427; *Statist. Summ. Miner. Ind.*, 1961 66, 324; *Annu. Rep. Dep. Atomic Energy, India*, 1967–68, 70).

Almost the entire production of rare earths in the country is exported, mainly to Europe, Japan and the U.S.A. The value of exports of Indian rare earths (compounds and concentrates) has shown a constant rise from Rs. 1.6 million in 1951–52 to Rs. 14 million in 1967–68. The Indian rare earth products are very well established in the international market [Johnstone & Johnstone, 586; *Chem. Engng World*, 1968, **3**(2), 65; *Nucl. India*, 1967, **6**(4), 4].

Raspberry — *see* **Rubus**

Ratel — *see* **Weasels**

RAUVOLFIA Linn. (*Apocynaceae*)

A large genus of shrubs or undershrubs or occasionally trees distributed in tropical Asia, Africa and America. Five species are recorded in India, including one which is introduced and naturalized. Of these *R. serpentina* has become well known as a medicinal plant.

Few drugs have attracted such a world-wide attention as the roots of *R. serpentina*. For centuries, the drug Rauvolfia has been used in the Ayurvedic system of medicine in India. It is only during the last

decade that the importance of the drug and of its major alkaloid reserpine, has been recognized in the allopathic system in the treatment of hypertension and as a sedative or tranquillizing agent. Major part of the commercial supply of the drug used in U.S.A. and European countries originates from India, Pakistan, Ceylon, Burma and Thailand, India being the major supplier. India, which holds almost a world monopoly, has been threatened with the depletion of wild resources of the plant, with the increasing demand. A few years back, the Government of India, therefore, restricted the export of crude drug, in order to conserve the natural growth from indiscriminate exploitation. This step resulted in an immediate shortage of *R. serpentina* roots and reserpine in world markets. Several of the large pharmaceutical houses abroad began an active search for other known species, as possible sources of reserpine. At present a number of other species, particularly *R. tetraphylla* in America and *R. vomitoria* in Africa have been found suitable, and attempts are being made to extract reserpine and other alkaloids from them (Woodson *et al.*, 11, 14, 32; Renier, *Bull. agric. Congo belge*, 1954, **45**, 1390; Feuell, *Colon. Pl. Anim. Prod.*, 1955, **5**, 1).

R. serpentina Benth. ex Kurz RAUVOLFIA ROOT, SERPENTINE OR SERPENTINA ROOT

D.E.P., VI(1), 398; Fl. Br. Ind., III, 632.

SANS.—*Sarpagandha, chundrika*; URDU—*Asrel*; HINDI—*Chandrabhaga, chota-chand*; BENG.—*Chandra*; MAR.—*Harkaya, harki*; TEL.—*Paataala-gani, paataala garuda*; TAM.—*Chivan amelpodi*; KAN.—*Sarpagandhi, shivanabhiballi, sutranavi, pata-lagandhi*; MAL.—*Chuvannavilpori, suvapaval-poriyan*; ORIYA—*Patalgarur, sanochado*.

DELHI—*Makalmaran*; MUNDARI—*Simjenga, araba, huring, supurolid, darujikipota*; ASSAM—*Arachon-tita*; KHASI—*Todong-pait-parao*; MIKIR—*Jowansu*.

TRADE—*Rauvolfia*.

An erect, evergreen perennating undershrub, 15–45 cm. (rarely 90 cm.) high; tap-root tuberous, soft, sometimes irregularly nodular; bark pale brown, corky with irregular longitudinal fissures; leaves in whorls of three, large, 7.5–17.5 cm. × 4.3–6.8 cm., elliptic-lanceolate or obovate, acute or acuminate, dark green above, pale green below; flowers white or pinkish, in many-flowered cymes; fruit a drupe, slightly connate, obliquely ovoid, purplish black; pyrenes slightly rugose.

R. serpentina is widely distributed in the sub-Himalayan tract from Punjab eastwards to Nepal, Sikkim and Bhutan, in Assam, in the lower hills of the Gangetic plains, eastern and western ghats, in some parts of Central India and in the Andamans. Beyond India, the plant is distributed in East Pakistan, Ceylon, Burma, Malaya, Thailand and Java. It is found usually in moist deciduous forests at altitudes ranging from sea level to 1,200 m.; it is seldom found in evergreen forests except at their very edges and is absent in open country. The plants are more frequent under the shade of *Shorea, Ficus, Terminalia, Holarrhena, Cassia, Dalbergia, Mangifera,* and *Adina* spp.; sometimes they are found growing between clumps of *Calamus*. In the Deccan, they are found associated predominantly with bamboo forests, particularly in freshly deforested areas. It is noteworthy that wherever plants of *R. serpentina* have been found, they are growing in close proximity to the beaten tract or to sites of habitation, whether ancient or recently abandoned. Such an association of *R. serpentina* with sites of human habitation cannot be considered entirely accidental (Santapau, *Indian J. Pharm.*, 1956, **18**, 117; Chandra, *J. Indian bot. Soc.*, 1957, **36**, 519; Varadarajan, *Econ. Bot.*, 1963, **17**, 133).

Although the range of distribution of *R. serpentina* is very wide, its occurrence is sporadic. The plants usually grow scattered, very seldom close to each other. At present commercial supplies of *R. serpentina* roots are available mostly from the States of Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Andhra Pradesh, Madras, Kerala, Mysore and Maharashtra (Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Santapau, loc. cit.; Srinivasan, *Pakist. J. sci. industr. Res.*, 1961, **4**, 188).

CULTIVATION

Despite their wide geographical distribution and edaphic tolerance, *Rauvolfia* species have not lent themselves to easy cultivation due to various factors which influence their propagation, growth and development and also their alkaloid content. At present all supplies of *R. serpentina* roots are furnished by wild plants. Since supplies from wild sources are limited, it may not be possible to maintain a sustained and steady supply at the present rate of exploitation. Further, indiscriminate collection of roots has already denuded many forest areas in Uttar Pradesh, West Bengal, Madras and Maharashtra of their natural growth, and their conservation has become essential.

Consequently, steps have been taken to limit the supplies from natural sources and have them substantially augmented through cultivation (Woodson *et al.*, 14; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258).

Experimental cultivation of this plant has been taken up in Uttar Pradesh (Dehra Dun), Bihar, parts of Orissa, West Bengal (Rongo), Assam, Madras, Kerala, Mysore, Maharashtra and Saurashtra (Gujarat). At Dehra Dun, intensive cultivation is being done by the Himalayan Drug Company. Among the research institutions, experiments on propagation of *R. serpentina* are in progress in the National Botanic Gardens, Lucknow, in Regional Research Laboratory, Jammu, and the Research Nursery at Indore, though on a small scale. A factory has been established in Orissa State to process the drug obtained from forests in Kalahandi region (Santapau, loc. cit.; Ahluwalia, *Indian For.*, 1963, **89**, 373; Chandra, *J. sci. industr. Res.*, 1956, **15A**, 125; Sobti *et al.*, *Indian For.*, 1959, **85**, 233; Srinivasan, loc. cit.).

There is little difference in the morphological features of *R. serpentina* roots obtained from various zones. However, the alkaloid content and potencies of roots vary not only in samples from representative and geographically distinct areas but also from lots coming from the same geographical area. One question possibly of vital importance in successful cultivation of *Rauvolfia* spp. concerns the correlation of profitable alkaloid production with age (and particularly reproductive maturity) of the plants (Sulochana, *J. Indian bot. Soc.*, 1959, **38**, 580; Rajagopalan, *J. sci. industr. Res.*, 1954, **13B**, 77; Woodson *et al.*, 14).

Climate and Soil—R. serpentina can grow under a wide range of climatic conditions. It flourishes in a hot humid condition and can be grown both in the open and in partial shade; it cannot stand the full open sun. In its native habitat, the plant thrives under the shade of forest trees or at the very edge of the forests where three of the four sides are protected against too intense an illumination. It prefers a tropical or sub-tropical belt having the benefit of monsoon rains, preferably the south-west. Localities in the Deccan Peninsula, which enjoy a more equitable climate throughout the year as compared to the sub-Himalayan tracts are said to be more suited to a profitable cultivation than the northern sub-Himalayan region (Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Santapau, loc. cit.; Varadarajan, *Econ. Bot.*, 1963, **17**, 133).

A climate with a range of temperature from 10 to 38° seems to be well suited for this plant. Best areas for its growth are those which combine high rainfall with proper drainage of the soil, such as slight slopes, etc. Although it has been reported to grow naturally where rainfall measures about 250 cm. annually, it grows well in areas with a rainfall of even 500 cm. or more. The plant is found to thrive well in areas with a wide disparity in rainfall such as Jamnagar, Jammu, Dehra Dun, western ghats and Rongo hills. Where rainfall is low, the plant can be successfully cultivated, if irrigation is made available during the drier months. Though the plant seems to be sensitive to water-logging, it can withstand water for 2–3 days without much damage. The plant sheds its leaves during cold months in localities with a severe winter, as in Dehra Dun. Frost kills the top tender green twigs only, and fresh shoots sprout up with the advent of spring from the thicker shoots which can withstand the frost (Varadarajan, loc. cit.; Santapau, loc. cit.; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258).

The plant grows in a wide variety of soils from sandy alluvial loam to red lateritic loam or stiff dark loam. In its natural habitat, it prefers clay or clayey loam with a large percentage of humus and other organic debris which ensure uniform moisture levels and a good drainage. The soil should be acidic with a *p*H about 4.0. Under cultivation, nitrogen may be supplied through fertilizers, farmyard manure or compost. Generally, the plant produces thicker roots in black, stiff loamy soils or red lateritic loam than in heavy clayey or sandy soil. Soils containing large quantities of sand retard growth of the plants and make them more susceptible to root and leaf diseases (Raghavan Nair, *Indian For.*, 1955, **81**, 168; Varadarajan, loc. cit.; Santapau, loc. cit.; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Kaul, *Indian J. Pharm.*, 1956, **18**, 127).

PROPAGATION

R. serpentina can be propagated by seeds, root cuttings, root stumps and stem cuttings.

Seed Propagation—Direct sowing of seeds in the field has not been found successful and hence seedlings are raised in the nursery and transplanted in the field. The germination percentage of seeds is very poor and variable (25–50%) and is often as low as 10 per cent. This is attributed partly to the adverse influence of the stony endocarp. A more serious factor is that in many species of the genus in both

RAUVOLFIA SERPENTINA—FLOWERING AND FRUITING BRANCHES

the hemispheres, fruits of perfectly normal external appearance contain no embryos, an effect possibly of parthenocarpy or of deferred somatoplastic sterility (Badhwar *et al.*, *Indian For.*, 1963, **89**, 729; 1955, **81**, 258; Abrol *et al.*, *Indian J. Pharm.*, 1956, **18**, 169; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Woodson *et al.*, 18).

Recently, it has been found that fresh seeds collected from ripe fruits, immediately before sowing showed a germination rate of 58–74 per cent. A delay of 24–36 hours between collection and sowing of seeds reduced their rate of germination. Sun-dried and stored seeds generally gave a low rate of germination and seeds stored for more than 7–8 months practically did not germinate. The ripe seeds, collected from the beginning of June to the end of October or even November and stored in air-tight tins, retained their viability for about six months (Choudhury, *Sci. & Cult.*, 1963, **29**, 156; Badhwar *et al.*, *Indian For.*, 1963, **89**, 729; Raghavan Nair, ibid., 1955, **81**, 168).

The nursery is preferably located in partially shaded area with irrigation facilities. The land is cleared of weeds and ploughed to a depth of 30 cm. It is supplied with well rotted farmyard manure and leaf mould each at the rate of 1.0 kg./sq. m. and the beds prepared to a fine tilth. Seeds are sown about the middle of May. They are soaked overnight and are drilled about 0.6 cm. deep in lines 7.5 cm. apart. As the roots of the seedlings penetrate deep into soil, close sowing should be avoided. About 5.5 kg. of seed sown in 0.05 hectare will yield seedlings sufficient to plant one hectare. The germination is gradual and the growth of seedlings slow. Sowings done at the break of monsoon and the seedlings transplanted in August suffer heavy mortality during winter in localities such as Dehra Dun, but may be successful in regions with a mild winter as in South India (Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243).

The area to be planted is ploughed deeply and a dosage of farmyard manure or compost at the rate of 30–37 cartloads per hectare is applied. Beds of suitable size with irrigation channels are laid and transplanting done during the rainy season. The seedlings, about 7.5–12.0 cm. high, are carefully dug up with their tap-root from the nursery beds and immediately transplanted in rows 60 cm. × 30 cm. apart, in holes 15–20 cm. deep. A mixed manure composed of about 40 kg. of farmyard manure, 20 kg. of bone meal, 2.5 kg. of ammonium sulphate and 40 kg. of leaf mould is applied to the transplanted seedlings, one handful to each hole. After transplanting, irrigation is given at regular intervals until the seedlings get established. Sometimes the rows are earthed up to facilitate drainage, when rainfall is high. About two weedings are done, once during the monsoon and another at the end of the growing season, about December, in order to maintain satisfactory development of roots. Manuring at the time of hoeing is desirable to get a high yield of roots (Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 293).

Vegetative Propagation—As collection of seeds from wild sources is both laborious and costly, vegetative propagation by root- or shoot-cuttings has been advocated for raising plantations. Propagation by means of seeds might prove ultimately even unwise, since variation in alkaloidal yield is apparently genetically controlled and might get reduced in successive progenies through adverse gene recombinations. Possible hybridization also appears difficult because of the usually small flowers and elaborate stigmatic structures; the difficulty becomes intensified by the self-fertility of at least some species such as *R. serpentina* and possibly *R. tetraphylla* (Badhwar *et al.*, *Indian For.*, 1963, **89**, 729; Woodson *et al.*, 18).

For propagation by root cuttings, large tap-roots with a few filiform lateral secondary rootlets are used. Cuttings, 2.5–5.0 cm. long are planted horizontally about 5 cm. below the surface or in holes. They are irrigated and nearly 50 per cent of the root cuttings, planted at the beginning of the monsoon sprout in about a month. Trials at Dehra Dun and other places have shown that under irrigated conditions root cuttings of about 0.25 cm. diameter planted during March–June gave 52–79 per cent success. In another study, cuttings of 1.25 cm. diameter rooted within 10–15 days, producing healthy roots and shoots. Thicker roots, split into pieces of 1.25 cm. diameter, have also been found to produce shoots normally. About 100 kg. of root cuttings are required to plant a hectare. The high percentage of successful plants obtained by root cuttings makes it preferable to propagation by seeds. However, the alkaloidal content of roots from them has been found to be not so high as in plants raised from seeds (Santapau, loc. cit.; Badhwar *et al.*, *Indian J. Pharm.*, 1956, **18**, 170; *Indian For.*, 1955, **81**, 258; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Chandra, *J. sci. industr. Res.*, 1954, **13A**, 187).

Propagation by root stumps was attempted using about 5 cm. of root with a portion of stem above the

collar. This method met with about 90–95 per cent success or sometimes even 100 per cent. Such plants transplanted in May–July in irrigated fields, become well established by the end of September. This method, however, has its limitation in that only one plant can be raised from a single stump (Badhwar *et al.*, *Indian J. Pharm.*, 1956, **18**, 170; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Santapau, *Indian J. Pharm.*, 1956, **18**, 117).

Stem cuttings taken from woody twigs have also been tried for propagation. Hardwood cuttings have been found better than softwood cuttings; cuttings, 15.0–23.0 cm. long, having three internodes are most suitable. Highest percentage (60–100%) of rooting was obtained by treating hardwood cuttings with β-indolyl acetic acid solution (30 p.p.m.) for 12 hours; treated cuttings rooted within 15 days. Stem cuttings planted in the nursery during early monsoon (June), and kept moist until they sprout, have given 40–65 per cent success. Such cuttings, though they start sprouting 3–4 days after planting, actually strike root mostly after about 75 days. Premonsoon planting has not been successful, in spite of copious irrigation and protection against sun. Stem cuttings have been found less satisfactory than root cuttings, since many of them do not root easily (Badhwar *et al.*, *Indian J. Pharm.*, 1956, **18**, 170; *Indian For.*, 1955, **81**, 258; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Santapau, loc. cit.; Chandra, *Indian J. Pharm.*, 1956, **18**, 132; *Sci. & Cult.*, 1954–55, **20**, 554).

Diseases and Pests

R. serpentina is susceptible to various diseases. Leaf spot, caused by *Cercospora rauvolfiae* Chupp & Muller manifests as spots of dark brown colour on the upper surface of the leaf and as yellowish brown on the lower surface. Olivaceous effuse fructification is produced on the lower leaf surface. The affected leaves turn yellow, become dry and subsequently fall off, resulting in defoliation (Mohanty & Addy, *Curr. Sci.*, 1957, **26**, 289).

Alternaria sp. attacks the leaves of *R. serpentina*, showing minute brownish, dark-coloured circular spots with yellowish margin on the ventral side of the leaves; these enlarge to prominent dark brown circular lesions. Diseased leaves finally turn brown and fall off. The fungus also affects the flowers and fruits (Chandra, *Sci. & Cult.*, 1955–56, **21**, 208; *Indian J. Pharm.*, 1956, **18**, 147).

Mosaic is a common disease on *R. serpentina*. The primary symptom comprises vein bending and gradual yellowing of leaves. Later, the leaf curls from the margin to the midrib on the abaxial surface and ultimately the leaf drops off (Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243).

Root knot appears as galls of various sizes, up to 8 mm. in diameter, covering the root system. Stunted growth of plants, etiolation and decrease in leaf size are the symptoms in the aerial portion. The galls on examination show mites, various soil fungi and nematodes (*Heterodora* sp.). Generally, brown clay soils supporting the natural growth of *R. serpentina*, are found to be infested with nematodes, while dark clay soils are free from them (Chandra, *Indian J. Pharm.*, 1956, **18**, 146; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Varadarajan, ibid., 1963, **17**, 133).

Other diseases recorded on *R. serpentina* are: leaf blotch caused by *Cercospora* sp.; leaf spot caused by *Pellicularia filamentosa* (Pat.) Rogers and *Epicoccum nigrum* Link; leaf blight and bud rot caused by *Alternaria tenuis* Nees; wilt caused by *Fusarium oxysporum* f. *rauvolfiae* Janar., Ganguly & Husain; powdery mildew caused by *Leveillula taurica* (Lev.) Arn.; and target spot caused by *Corynespora cassiicola* (Berk. & Curt.) Wei. *Mycosphaerella rauwolfiae* Ramakrishnan & Ramakrishnan is reported to occur on leaves of *R. serpentina* (Chandra, *Sci. & Cult.*, 1957–58, **23**, 99; Varadarajan, *Curr. Sci.*, 1964, **33**, 503; Srivastava, *Proc. nat. Acad. Sci. India*, 1964, **34B**, 188; Ganguly & Pandotra, *Indian Phytopath.*, 1962, **15**, 50; Janardhanan *et al.*, *Curr. Sci.*, 1964, **33**, 313; Mohanty, *Sci. & Cult.*, 1957–58, **23**, 608; Butler, Bisby & Vasudeva, 63).

Very few pests have been recorded on *R. serpentina*. A pyralid caterpillar (*Glyphodes vertumnalis* Guen.) causes appreciable damage to the leaves. The caterpillars roll the leaves and remain inside the rolls feeding on the green matter. Some other caterpillars (*Daphnis nerii* Linn. and *Deilephila nerii* Linn.) are also reported to feed on the tender leaves causing defoliation of the plant. Cockchafer grubs (*Anomala polita* Blanch.) attack the seedlings about 2 cm. below the hypocotyl, resulting in their drying up. Rats sometimes cause damage by nibbling through the tender twigs. Control by cyanogas or by flooding has been suggested. *R. serpentina* is not eaten by cattle or any other grazing animals (Sivagami & Narayanaswamy, *Madras agric. J.*, 1962, **49**, 415; Patel & Patel, *Indian J. Ent.*, 1967, **29**, 97; Chandra & Gulati, *Sci. & Cult.*, 1966, **32**, 329; *Indian For.*, 1965, **91**, 579; Badhwar *et al.*, ibid., 1955, **81**, 258; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243).

Harvesting and Yield

Harvesting—Roots of exploitable size are generally collected 2–3 years after planting. It is reported that the roots dug out in winter (December) in Dehra Dun, when the plants have shed their leaves, are far richer in the total alkaloid content than the roots harvested in August. Roots are dug up, freed from the adhering soil and thoroughly air-dried and packed usually in gunny bags. On air-drying, the moisture content of roots drops to 12–20 per cent, but roots containing less than 8 per cent of moisture store better; this can be brought about by artificial drying. The root bark constitutes 40–56 per cent of the whole roots and contains more alkaloid than the woody portion. Hence care should be taken to keep the bark intact while harvesting. Packing in air-tight containers is advisable as roots with high moisture content soon become mouldy and give low yield of total alkaloids (Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; *Indian J. Pharm.*, 1956, **18**, 170; Gupta, ibid., 1956, **18**, 179; Rajagopalan, *J. sci. industr. Res.*, 1954, **13B**, 77; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Santapau, *Indian J. Pharm.*, 1956, **18**, 117).

FIG. 141—RAUVOLFIA SERPENTINA—FRESH ROOTS (×0.5)

Yield of roots—Though *R. serpentina* can be propagated by various methods, optimum yield of roots (including thick, thin and fibrous) is obtained when propagation is done by seeds. The yield of fresh roots per plant varies widely from 0.1 kg. to 4.0 kg. With a spacing of 60 cm. x 30 cm. and a survival percentage of 80, the total yield of roots in the case of plants raised from seeds works out to about 1,175 kg. (air-dry basis) per hectare as compared with 175 kg. in the case of plants raised from stem cuttings and 345 kg. in the case of plants raised from root cuttings. A yield of 2,200 kg. of air-dried roots per hectare has been obtained from a 2-year old plantation and 3,300 kg. from a 3-year old plantation under irrigated agricultural conditions on sandy clay loam soil. Manurial experiments showed that judicious use of farmyard manure and ammonium sulphate as top dressing helps in obtaining a larger yield of roots (Badhwar *et al.*, *Indian For.*, 1963, **89**, 729; 1955, **81**, 258; Raghavan Nair, ibid., 1955, **81**, 168; Badhwar *et al.*, *Indian J. Pharm.*, 1956, **18**, 170).

The roots are commonly adulterated with other parts of the plant such as the stems, and root stumps with some portions of stem attached to them; roots having an excess of moisture content are also used. Roots of other *Rauvolfia* species such as *R. beddomei*, *R. densiflora*, *R. micrantha*, *R. perakensis* and *R. tetraphylla* and those of *Ophiorrhiza mungos*, and white- and red-flowered *Clerodendrum* spp. have also been found as adulterants. Among commercial supplies, roots of types from coastal plains and Malabar are reported to be moderately or grossly adulterated. Stems of the plant contain less quantity of alkaloids, and hence adulteration of roots with stems lowers the total alkaloidal content of samples. The roots can be easily distinguished from the stems since they have a more wrinkled surface, are less flexible, thicker, more tortuous and less branched (Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; *Indian J. Pharm.*, 1956, **18**, 181; Mukerji, ibid., 1956, **18**, 433; Holt & Costello, *J. Amer. pharm. Ass., sci. Edn*, 1954, **43**, 144; Youngken, ibid., 1954, **43**, 70, 141; Rajagopalan, *J. sci. industr. Res.*, 1954, **13B**, 77).

Seed Collection

Plants flower six months after planting or even earlier, if the temperature is high. The flowering habit of the plant varies with climatic conditions. In the foot-hills of North-West Himalayas, e.g. in Dehra

Dun and Jammu, where minimum winter temperature falls to about 5°, plants undergo a period of dormancy from December to early March, when the leaves, flowers and fruits are shed. With the advent of spring, new leaves appear in March, followed by flowers and fruits. Profuse flowering occurs from July to September; but in other places in India, the plant flowers nearly all the year round (Biswas, *Indian J. Pharm.*, 1956, **18**, 227; Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243).

Collection of mature seeds is usually done from September to February. Fruits mature from July to November. Only a few fruits ripen at a time, and if they are not collected immediately they are shed and lost. Therefore, collection of ripe fruits, twice a week, is necessary. While this is easy in the case of plantations, collection from plants growing wild is both laborious and costly owing to their scattered distribution over wide areas. The fruits after collection are freed from their pulpy covering by rubbing them against old gunny bags or on rough flooring. The cleaned seeds are thoroughly dried in the sun and stored in a dry place or in air-tight containers. A yield of 98–122 kg. of clean seed can be collected from a hectare of a 3-year old plantation (Dutta *et al.*, *Econ. Bot.*, 1963, **17**, 243; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258).

For seed collection a cultivated crop of 2- or 3-year standing could be used before digging out the roots. Adequate supply of seeds can also be obtained by raising the plants vegetatively in compact areas preferably by using stem cuttings (Badhwar *et al.*, *Indian J. Pharm.*, 1956, **18**, 170; *Indian For.*, 1955, **81**, 258).

Production and Trade

Production—Reliable data on the exact quantity of rauvolfia roots, available for commercial purposes from different States in India or the quantity of roots annually consumed are not available. Information on some of these aspects is, however, available in respect of a few areas and they are only approximate estimates. The areas and the annual output known are: Vishakhapatnam in Andhra Pradesh, 2.2 tonnes; Assam, 40–50 tonnes; Buxa and Cooch-Behâr in West Bengal, 8 tonnes; East Bastar and Bindrawagarh in Madhya Pradesh, 0.5 tonne. In North Bastar (Madhya Pradesh), 24,000 plants are estimated to be available. In Bihar, Sikkim, Tripura, Himachal Pradesh, Punjab, Madhya Pradesh, Mysore and the Andaman Islands, plants are too scarce and as such, commercial exploitation from these areas may not be promising (Srinivasan, *Pakist. J. sci. industr. Res.*, 1961, **4**, 188).

Recently, attempts at systematic collection of roots have been taken up in some areas. In Andhra Pradesh, the forest department collects the roots, dries them and sells them in open auction. In Maharashtra and Mysore, restrictions on collection have been imposed and the roots cannot be collected from the forest areas without permission. In Orissa, even though commercial supplies are available, they are not fully exploited and the privilege of collection is given to selected lessees. However, a condition is made in the agreement that the lessee should restock the area worked, by planting a small stump of root with a portion of the stem above the collar. In Buxa and Cooch-Behar Forest Divisions (West Bengal), additional supplies can be expected but these are not collected at present due to lack of prospective buyers (Srinivasan, loc. cit.).

Trade—Rauvolfia roots are usually marketed under the names of their geographical sources and are designated as Assam, Bengal, Bihar, Dehra Dun, Himalayan, Coastal Plain, Malabar and Ceylon types. There is a steady demand for the roots and most of the produce is exported, because only a small fraction is used by the Indian pharmaceutical firms. The important centres of marketing are Delhi, Amritsar, Saharanpur, Calcutta and Bombay.

Major part of export from India is to Europe, U.S.A. and Japan (Table 1). The supplies in recent years have fallen short of demand, due to the restric-

TABLE 1—EXPORTS OF RAUVOLFIA SERPENTINA ROOTS FROM INDIA

(Qty in kg.; Val. in Rs.)

	1963-64	1964-65	1965-66	1966-67*	1967-68
U.S.A.	97,156	9,975	14,740	8,928	..
Germany	11,842	59,254	11,565	2,110	1,362
Japan	14,883	4,000	11,500	4,900	10,450
Belgium	500	12,666	6,932	..	..
U.K.	11,188	9,950	5,175	4,200	3,800
France	..	43,905	3,845	6,352	4,896
Others	13,533	4,906	40	3,021	80
Total (Qty)	149,102	144,656	53,797	29,511	20,588
Value (Rs.)	2,220,815	2,087,893	738,905	448,162	331,656

* June 1966 March 1967.

TABLE 2—EXPORTS OF RAUVOLFIA ALKALOIDS FROM INDIA

(Qty in kg.; Val. in Rs.)

	1963 64	1964–65	1965 66	1966 67*	1967 68
Malaya	194	135	95	..	32
Pakistan	460	586	317	..	..
Japan	..	..	1,500	500	500
Others	13	..	50	286	34
Total (Qty)	667	721	1,962	786	566
Value (Rs.)	16,692	14,820	87,415	48,565	43,184

* June 1966-March 1967.

tions imposed by the Government of India. Besides roots, a small quantity of rauvolfia alkaloids is exported annually (Table 2).

Rauvolfia Drug

The drug rauvolfia consists of the air-dried roots of *R. serpentina*. The roots are stout, up to 40 cm. long, 2 cm. in diameter, tortuous; surface slightly wrinkled, rough and coarse with longitudinal markings; sometimes branched; fracture short and irregular; root bark greyish yellow to brownish; wood pale yellow. The roots are odourless and very bitter. Rauvolfia is official in Indian Pharmacopoeia which requires that the roots should be collected, with the bark intact, in autumn from 3 to 4 year-old plants; they should contain: total alkaloids, ≮0.8%; and foreign matter, ≯2.0%. The British Pharmaceutical Codex requires the content of reserpine-like alkaloids to be not less than 0.15 per cent. Besides the root, its liquid extract, the dried extract, and the tincture are official in Indian Pharmacopoeia (Youngken, *Amer. J. Pharm.*, 1953, **125,** 186; Woodson *et al.*, 33; I.P., 226, 227, 524, 693; I.P.C., 217; B.P.C., 1963, 701).

In recent years, rauvolfia and its preparations have become important therapeutic agents, both as antihypertensives and as sedatives. Rauvolfia is an important source of the active alkaloid, reserpine, which is also extracted commercially from the roots of *R. vomitoria* and *R. tetraphylla*; reserpine content of *R. vomitoria* is twice that of *R. serpentina*. In India, rauvolfia has been employed for centuries for the relief of various central nervous system disorders, both psychic and motor, including anxiety states, excitement, maniacal behaviour associated with psychosis, schizophrenia, insanity, insomnia and epilepsy. Extracts of the roots are valued for the treatment of intestinal disorders, particularly diarrhoea and dysentery and also as anthelmintic. Mixed with other plant extracts, they have been used in the treatment of cholera, colic and fever. The root was believed to stimulate uterine contraction and recommended for use in child-birth in difficult cases. The juice of the leaves has been used as a remedy for opacity of the cornea [U.S.D., 1955, 1826; Schlittler in Manske, VIII, 288; Mukerji, *J. sci. industr. Res.*, 1955, **14A**(7), suppl., 1; Kirt. & Basu, II, 1550].

Rauvolfia Alkaloids

The pharmacological activity of rauvolfia is due to the presence of several alkaloids of which reserpine is the most important. The total alkaloid content of the roots from different sources varies considerably; it normally ranges from 1.7 to 3.0 per cent. Table 3 gives the alkaloid content of the roots obtained from various sources in India. There does not seem to be any striking difference in the alkaloid content of the roots with respect to the age of the plant up to 3–4 years of its growth (Table 4). The alkaloids are concentrated mostly in the bark of the roots, the quantity being much less in the wood; the bark is reported to yield about 90 per cent of the total alkaloidal

TABLE 3—TOTAL ALKALOID CONTENT OF THE ROOTS OF R. SERPENTINA OBTAINED FROM VARIOUS PARTS OF INDIA

Place	Source	Age of the plant	Alkaloid content (%)
Assam[1]	Trade	..	2.57
Bihar[1]	do.	..	2.24
Bihar[2]	..	..	0.96 2.72
Madhya Pradesh[1]	Trade	..	2.99
Madhya Pradesh (Bastar)[1]	do.	..	2.41
Orissa[1]	do.	..	1.73
Uttar Pradesh[1]	do.	..	2.05
Kerala[1]	do.	..	1.86
West Bengal			
Darjeeling[1]	do.	..	1.76
Plains[1]	Cultivated	12 months	1.94
Gujarat (Jamnagar)[4]	do.	30 months	1.85
Rajasthan			
Bundi[3]	do.	15 months	1.76
Chittorgarh[3]	do.	17 months	1.78
Punjab (Shahpur)[3]	do.	18 months	1.17
Western ghats[1]	Trade	..	1.17 1.73

[1] Ganguli & Bose, *Indian J. Pharm.*, 1956, **18,** 193; [2] Wakhloo, *J. Indian bot. Soc.*, 1963, **42,** 214; [3] Datta & Virmani, *Bull. nat. bot. Gdns, Lucknow*, No. 107, 1964; [4] Rajagopalan, *J. sci. industr. Res.*, 1954, **13B,** 77.

TABLE 4—ALKALOID CONTENT OF ROOTS OF R. SERPENTINA OF DIFFERENT AGES

Age (yr.)	Alkaloid content (%) Dehra Dun*	Jammu†	Anaimalais*	Kotah‡
1	1.81–2.02	1.66	1.37	1.24
2	1.65–1.78	1.54	2.05[a]	1.31
3	1.43–1.79	1.60	2.30	1.50

* Datta & Virmani, *Bull. nat. bot. Gdns, Lucknow*, No. 107, 1964; † Sobti *et al.*, *Indian For.*, 1959, **85**, 233; ‡ Mathur & Singh, ibid., 1965, **91**, 239.
[a] Roots obtained from 1½-year old plant.

TABLE 5—ALKALOID CONTENT OF DIFFERENT PARTS OF R. SERPENTINA

(%, dry basis)

Locality	Root	Root bark	Root wood	Leaf	Stem
West Bengal					
Plains[1]	1.94	4.13	0.5	..	..
Kumani Forest[2]	1.64	3.26	0.46	0.48	0.45
Kanchlori[3]	1.41	2.52	0.26	0.44	0.30
Jamnagar[1]	1.72	..	..	0.53	0.60

[1] Ganguli & Bose, *Indian J. Pharm.*, 1956, **18**, 193; [2] Biswas, ibid., 1956, **18**, 227; [3] Ahluwalia, *Indian For.*, 1963, **89**, 373.

content. The leaves and stems also contain alkaloids but in smaller amounts than the root bark (Table 5) (Ganguly & Bose, *Indian J. Pharm.*, 1956, **18**, 193; Badhwar *et al.*, *Indian For.*, 1955, **81**, 258; Mathur & Singh, ibid., 1965, **91**, 239; Bal, *Indian J. Pharm.*, 1956, **18**, 175).

The alkaloid content of the roots is reported to vary with the season. Experiments carried out in Dehra Dun have indicated that the roots dug out in December, when the plant sheds its leaves, are richer in alkaloids than the roots harvested in August. Investigations in Bihar also have given similar results: the alkaloid yield is highest at the end of the season when the plant sheds its foliage, and lowest at the beginning of the season when the growth is resumed. No significant difference has been observed in the alkaloid content of the roots of plants grown under irrigated agricultural and under forestry conditions (Biswas, *Indian J. Pharm.*, 1956, **18**, 227; Wakhloo, *J. Indian bot. Soc.*, 1963, **42**, 214; Badhwar *et al.*, loc. cit.).

There is a considerable increase in the yield of roots as well as their total alkaloid content when the plants are treated with colchicine. The maximum amount of fresh weight of root per tetraploid plant ($2n=44$) was 414 g. as compared to 250 g. for a diploid ($2n=22$), and the alkaloid content of the tetraploid was 2.3 per cent as against 1.5 per cent in a diploid of the same age. In another set of experiments, it was observed that the total alkaloid in the colchicine-induced tetraploid increased significantly, though there was no proportionate increase in reserpine content (Bhaduri & Biswas, *Sci. & Cult.*, 1955–56, **21**, 197; Janaki Ammal, *Curr. Sci.*, 1962, **31**, 520).

The alkaloids so far reported from various *Rauvolfia* spp. number about 80; they are listed, and classified according to chemical types in Table 6. The alkaloids isolated from the roots of *R. serpentina* and other *Rauvolfia* spp. found in India are given in Table 7. The presence and the quantity of individual alkaloids in *R. serpentina* appear to depend to a certain extent on the source from which the root is obtained. Considerable variation in the alkaloid content and potency of the roots obtained from different localities in India, as well as the lots coming from the same areas has been observed [Mukerji, *J. sci. industr. Res.*, 1955, **14A**(7), suppl., 1].

The known rauvolfia alkaloids can all be regarded as yohimbinoid derivatives. They are broadly classified into five types of basic chromophoric systems, viz. indole (including anhydronium bases), indoline, indolenine, oxindole and ψ-indoxyl, which have been further divided under their gross skeletal structures (Table 6). The alkaloids were earlier classified into three groups, viz. strong yellow anhydronium bases (e.g. serpentine), medium basic indolines (e.g. ajmaline), and weakly basic indolines (e.g. ajmalicine and reserpine). Pharmacologically, they can be divided into the reserpine group and the ajmaline group: the former releases the sympathomimetic amines whereas the latter does not. In the account below, only the pharmacologically active alkaloids of rauvolfia are dealt with (Schlittler in Manske, VIII, 296; Pakrashi & Achari, *J. sci. industr. Res.*, 1968, **27**, 58; Woodson *et al.*, 51; Arora *et al.*, *Indian J. med. Res.*, 1967, **55**, 389).

Reserpine—Reserpine is pharmacologically the most potent alkaloid, found in all the *Rauvolfia* spp. with the exception of a few. Reserpine content of the roots of *R. serpentina* obtained from different places in India is given in Table 8.

Reserpine is a relatively weak tertiary base occurring in the oleoresin fraction of the roots of *R. serpentina*. It is the 3,4,5-trimethoxy benzoic acid ester of

TABLE 6—ALKALOIDS OF RAUVOLFIA SPP.*

Alkaloid	Mol. formula	m.p.	$[\alpha]_D$
	INDOLE ALKALOIDS		
	(a) Yohimbine type		
Canembine (?)	$C_{22}H_{28}N_2O_5$	228–29°	+57° (ethanol)
Corynanthine	$C_{21}H_{26}N_2O_3$	231–32°	−85° (pyridine)
Seredine	$C_{23}H_{30}N_2O_6$	291°	−1°
Yohimbine	$C_{21}H_{26}N_2O_3$	234–36°	+101° (pyridine)
α-Yohimbine	$C_{21}H_{26}N_2O_3$	238–39°	−12°
β-Yohimbine	$C_{21}H_{26}N_2O_3$	246–49°	54° (pyridine)
3-Epi-α-yohimbine	$C_{21}H_{26}N_2O_3$	125–28° 181–83° 222–23°	−93°
ψ-Yohimbine	$C_{21}H_{26}N_2O_3$	268°	+27° (pyridine)
	(b) 18-Hydroxy-yohimbine type		
Deserpidine	$C_{32}H_{38}N_2O_8$	228–32°	−137°
Isopseudoreserpine	$C_{32}H_{38}N_2O_9$	..	..
Isoraunescine	$C_{31}H_{36}N_2O_8$	241–42°	70°
Isoreserpine	$C_{33}H_{40}N_2O_9$	152–56°	−164°
Raugustine	$C_{32}H_{38}N_2O_9$	160–70°	−50°
Raunescine	$C_{31}H_{36}N_2O_8$	160–70	−74°
Renoxidine	$C_{33}H_{40}N_2O_{10}$	238–41°	−100°
Rescidine	$C_{31}H_{40}N_2O_9$	183–86°	63°
Rescinnamine	$C_{35}H_{42}N_2O_9$	237–38°	−97°
Reserpic acid methyl ester	$C_{23}H_{30}N_2O_5$	244–45°	99°
Reserpine	$C_{33}H_{40}N_2O_9$	264–65°	117°
ψ-Reserpine	$C_{32}H_{38}N_2O_9$	257–58°	−65°
	(c) 19-Dehydro-18-hydroxy-yohimbine type		
Deserpideine	$C_{32}H_{36}N_2O_8$	149–52	−133° (pyridine)
Ranjemedine	$C_{34}H_{38}N_2O_9$	144–50°	88°
	(d) Hetero-yohimbine type		
Ajmalicine	$C_{21}H_{24}N_2O_3$	253–54°	62
Aricine	$C_{22}H_{26}N_2O_4$	190	59 (ethanol)
Isoreserpiline	$C_{23}H_{28}N_2O_5$	211–12°	−82° (pyridine)
Isoreserpinine	$C_{22}H_{26}N_2O_4$	225–26°	−18°
Rauniticine	$C_{21}H_{24}N_2O_3$	233–35	−38
Raunitidine	$C_{22}H_{26}N_2O_4$	276–78°	−70°
Raumitorine	$C_{22}H_{26}N_2O_4$	138°	+60°
Rauvanine	$C_{23}H_{25}N_2O_4$	129–35	+32°
Reserpiline	$C_{23}H_{28}N_2O_5$	..	12°
Reserpinine	$C_{22}H_{26}N_2O_4$	243–44	−131°
Tetrahydro-alstonine	$C_{21}H_{24}N_2O_3$	228–30	−102°
Tetraphylline	$C_{22}H_{26}N_2O_4$	220–23	−78°
	(e) Anhydronium type		
Alstonine	$C_{21}H_{20}N_2O_3$	>300	..
Serpentine	$C_{21}H_{20}N_2O_3$	158	+292° (methanol)
Serpentinine	$C_{42}H_{44}N_4O_6$	265–66	+117°
	(f) Sarpagine type		
Neosarpagine	$C_{19}H_{22}N_2O_3$	390°	..
Sarpagine	$C_{19}H_{22}N_2O_2$	>350°	+53° (pyridine)

Alkaloid	Mol. formula	m.p.	$[\alpha]_D$
	INDOLINE ALKALOIDS		
	Ajmaline type		
Ajmalidine	$C_{20}H_{24}N_2O_2$	241–42°	..
Ajmaline	$C_{20}H_{26}N_2O_2$	158–60°	+141°
Mauiensine	$C_{20}H_{24}N_2O$	240–42°	+184° (methanol)
Isoajmaline	$C_{20}H_{26}N_2O_2$	264–66°	+72°
Mitoridine	$C_{20}H_{22}N_2O_2$	322°	+175° (pyridine)
Picrinine	$C_{20}H_{22}N_2O_3$	216°	..
Purpeline	$C_{21}H_{24}N_2O_2$	155°	+333°
Rauvomitine	$C_{30}H_{34}N_2O_5$	115–17°	−173°
Rauwolfinine	$C_{20}H_{26}N_2O_2$	235–36°	35° (ethanol)
Sandwicine	$C_{20}H_{26}N_2O_2$	..	+180°
Seredamine	$C_{21}H_{26}N_2O_2$	297°	+60°
Tetraphyllicine	$C_{20}H_{24}N_2O_2$	320–22°	+61°
Vincamajine	$C_{22}H_{26}N_2O_3$	225°	−55° (ethanol)
Vomalidine	$C_{21}H_{26}N_2O_4$	242–43°	+318°
	ψ-INDOXYL ALKALOID		
Isoreserpiline-ψ-indoxyl	$C_{23}H_{28}N_2O_6$	252–54°	−254°
	INDOLENINE ALKALOIDS		
Perakine	$C_{21}H_{22}N_2O_3$	183°	+112°
Vomilenine	$C_{21}H_{22}N_2O_3$	207°	−72° (pyridine)
	OXINDOLE ALKALOIDS		
Carapanaubine	$C_{23}H_{28}N_2O_6$	221–23°	−101°
Rauvoxine	$C_{23}H_{28}N_2O_6$	210	+98°
Rauvoxinine	$C_{23}H_{28}N_2O_6$	203°	+64°
	ALKALOIDS OF UNKNOWN STRUCTURE		
Ajmalinine	$C_{20}H_{26}N_2O_4$	180–83	−97°
Alkaloid A	..	140°	+133°
Alkaloid D	..	184	+44°
Alkaloid RP1	$C_{22}H_{26}N_2O_4$	..	..
Alkaloid RP2	$C_{21}H_{25}N_2O_4$	..	..
Alkaloid RP3	$C_{21}H_{32}N_2O_6$	..	..
Amsoniaefoline	$C_{22}H_{32}N_2O_6$	220–23	..
An alkaloid	$C_{11}H_{16}N_2$	190–92	−132 (?)
Chandrine	$C_{25}H_{40}N_2O_8$	230–31	..
Neoreserpiline	$C_{23}H_{28}N_2O_5$	129–30°	−78 (ethanol)
Obscuridine	..	228°	..
Obscurine	..	255°	+250°
Pelirine	$C_{21}H_{26}N_2O_3$	130–31°	−121° (ethanol)
Raucaffricine	$C_{26}H_{32}N_2O_8 \cdot \frac{1}{2}H_2O$	220	+14.5° (ethanol)
Raucaffridine	$C_{21}H_{24}N_2O_3$	221°	..
Raucaffriline	$C_{21}H_{22}N_2O_4$	200–01°	..
Raunamine	$C_{25}H_{30}N_2O_4$	206–07	+60°
Rauwolfine	$C_{20}H_{26}N_2O_3$	235–36	..
Sandwicensine	$C_{19}H_{22}N_2O$	260–62°	+56° (methanol)
Samatine	$C_{21}H_{32}N_2O_7$	284–85°	..
Semperflorine	$C_{21}H_{26}N_2O$	295°	..

* Pakrashi & Achari, *J. sci. industr. Res.*, 1968, **27**, 58; Schlittler in Manske, VIII, 287.

TABLE 7—ALKALOIDS ISOLATED FROM RAUVOLFIA SPP. FOUND IN INDIA

Species	Alkaloids
R. beddomei[1]	Ajmalicine, sarpagine, serpentine
R. densiflora[1,2]	Ajmaline, densiflorine, rescinnamine, reserpiline, isoreserpiline, reserpine, reserpinine, sarpagine
R. micrantha[1]	Ajmalicine, raunamine, reserpiline, reserpine, sarpagine, neosarpagine, serpentine
R. serpentina[1,3]	Ajmalicine, ajmaline, isoajmaline, ajmalinine, chandrine, rauwolfinine, renoxidine, rescinnamine, reserpiline, reserpine, reserpinine, sarpagine, serpentine, serpentinine, tetraphyllicine, yohimbine, 3-epi-α-yohimbine
R. tetraphylla[1]	Ajmalicine, ajmaline, alstonine, aricine, corynanthine, deserpidine, raujemidine, raunescine, isoraunescine, renoxidine, reserpiline, isoreserpiline, reserpine, ψ-reserpine, reserpinine, isoreserpinine, sarpagine, serpentine, serpentinine, tetraphyllicine, tetraphylline, yohimbine, α-yohimbine, β-yohimbine, ψ-yohimbine

[1] Schlittler in Manske, VIII, 289 92; [2] Purohit & Majumdar, *J. Instn Chem. India*, 1963, **35**, 131; [3] Siddiqui, *Pakist. J. sci. industr. Res.*, 1958, **1**, 3.

TABLE 8—RESERPINE CONTENT OF ROOTS OF R. SERPENTINA FROM DIFFERENT LOCALITIES

Locality	Age (yr.)	Total alkaloids	Reserpine
Sagara[1] (Mysore)	1	1.74	0.12
Nilgiris[2] (Madras)		2.30	0.20
Bareilly[1] (U.P.)		2.14	0.15
Haldwani[2] (U.P.)		2.38	0.17
Dehra Dun[1] (U.P.)		2.12	0.06
Jammu[1]		1.6	0.05
Shahpur[1] (Maharashtra)		2.02	0.11
Nawapur[1] (Maharashtra)		1.49	0.12

[1] Datta & Virmani, *Bull. nat. bot. Gdns, Lucknow*, No. 107, 1964; [2] Gupta, *ISI Bull.*, 1968, **20**, 363.

reserpic acid, an indole derivative of 18-hydroxy-yohimbine type. Its activity is basically associated with the shape and structure of the molecule. Reserpine has been synthesized and the synthetic alkaloid is today competitive in price with reserpine extracted from the roots. Reserpine is official in the British Pharmacopoeia which includes the product obtained from *Rauvolfia* spp. or by synthesis (Schlittler in Manske, VIII, 296, 300, 316; Lewis, *J. Pharm., Lond.*, 1956, **8**, 465; Schlittler in CNS Drugs, 1, 8).

Reserpine has a depressant action on central nervous system and produces sedation and a lowering of blood pressure, accompanied by bradycardia. Administered orally, in hypertension, the effects of reserpine are slow, seldom appearing before 3–6 days of administration and continuing for some time after withdrawal of the drug; it has a cumulative effect. It is most valuable in young patients with mild labile hypertension associated with tachycardia. In long established hypertension, it is best used in conjunction with more potent hypertensive drugs such as hexamethonium or hydralazine. Combined with polythiazide, it is a useful hypotensive in mild to moderate conditions; with lasix it is particularly effective in patients with high mean values. The response to reserpine varies in patients and the dosage must be adjusted to individual requirements. In severe hypertension, it may be given by intravenous or intramuscular injection when the effect begins within a few hours. Parenteral therapy of reserpine is indicated in the treatment of hypertension, only when oral administration is impracticable (B.P.C., 1963, 704; U.S.D., 1955, 1825; Shah *et al.*, *J. Ass. Physicians India*, 1965, **13**, 845; *Chem. Abstr.*, 1965, **63**, 3523).

Reserpine is used for its sedative action in mild anxiety states and chronic psychoses. It has a tranquillizing rather than a hypnotic action and produces less somnolence than do barbiturates. Patients with chronic mental illness treated with reserpine often become relaxed, sociable and co-operative. It is administered by mouth and/or by intramuscular injection and the dosage is adjusted according to the response of the patient. The treatment may have to be continued over a long period of time and the drug should not be abruptly withdrawn. Reserpine is considered valuable in the treatment of chronic schizophrenic patients. It acts synergistically with chlorpromazine leading to lower dosage and minimizing adverse side effects (B.P.C., 1963, 704; Randrup & Munkvad, *Brit. J. Psychiat.*, 1966, **112**, 173; *Chem. Abstr.*, 1960, **54**, 12389).

The mechanism of antihypertensive and sedative effects of reserpine is not fully known yet. Administration of reserpine depletes the brain and peripheral vessels of serotonin (5-hydroxy tryptamine) and catechol amines. It has been postulated that its primary attack on the brain leads to sedation, whereas its secondary action on the peripheral vessels produces antihypertensive effects. However, no causal relationship between depletion of amines and the sedative and antihypertensive activities in response to reserpine

has been firmly established. It has also been suggested that the action of reserpine on the central nervous system is partly due to its influence on the circulating hormones (Bein in Chen & Mukerji, 87 92 ; Schlittler in CNS Drugs, 2 ; Schildkraut & Kety, *Science*, 1967, **156**, 21 ; *Chem. Abstr.*, 1964, **60**, 3400).

Reserpine has a highly complex pattern of activity. Besides the amine concentration in brain, it is also reported to influence the concentration of glycogen, acetylcholine, γ-aminobutyric acid, nucleic acids, anti-diuretic hormone, and substance P. The effects of reserpine include respiratory inhibition, stimulation of peristalsis, myosis, relaxation of nictating membranes, and influence on the temperature regulating centre. It increases the volume and free acidity of gastric secretion. Reserpine reduces glycaemia in some cases but the effect is short-lived. In some patients it has a stimulating effect on pro-thrombin activity. Reserpine also favours permeation of blood into areas rendered ischemic by burns (Bein in Chen & Mukerji, 87 92 ; *Ann. N.Y. Acad. Sci.*, 1955, **61,** 4 ; Woodson *et al.*, 119–29 ; Martindale, I, 742 ; *Chem. Abstr.*, 1965, **63,** 17002 ; 1966, **64,** 20491 ; 1965, **62,** 5689 ; Vavrik, *Experientia*, 1965, **21,** 701).

Reserpine should be used with caution in anxiety-depressive states and in patients with cardiac arrhythmia, myocardial infarction or severe cardiac damage, bronchitis, asthma or gastric ulcer. Reserpine has a relatively low toxicity, but even the minimum therapeutic doses may give rise to nasal congestion, lethargy, drowsiness, peculiar dreams, vertigo and gastro-intestinal upsets ; sometimes dyspnoea and urticarial rash may occur. Higher doses may cause flushing, injection of conjunctivae, insomnia, brady-cardia, occasionally parkinsonism, and severe mental depression which may lead to suicide. Cases of asthenia and oedema have also been reported. Side effects of reserpine are usually transient and quickly disappear on reducing the dosage or discontinuing treatment. Tolerance to reserpine does not develop and it does not appear to be habit-forming. Prolonged previous use of reserpine may cause disturbances in blood pressure during operation under general anaes-thesia, while some patients may be highly susceptible to a small parenteral dosage. When give to nursing mothers to increase the secretion of milk, it is excreted with milk but the amount is not therapeutically harmful (B.P.C., 1963, 704 ; *Chem. Abstr.*, 1966, **65,** 4505 ; 1965, **63,** 13862 ; Leonberg *et al.*, *Ann. intern. Med.*, 1964, **60,** 866).

Reserpine is now being used as a tool in physio-logical studies of body functions and pharmaco-logical studies of other drugs. It is effective against ligation-induced fibrillation of dog heart. It interrupts the normal vaginal cycles, inhibits the ovulation and induces pseudo-pregnancy in female rats. In male rats it tends to inhibit the androgenic secretions of gonads and to decrease the compensatory hypertrophy of testes. It is reported to give some protection to male and female mice against the sterilizing effect of hormones. Reserpine exhibits anti-emetic activity against staphylococcal enterotoxin and apomorphine-induced vomiting in experimental animals. It is antagonistic to the analgesic effect of morphine and increases the survival rate of mice exposed to X- and γ-rays. Skin homograft rejection in rats is decreased under reserpine treatment. Reserpine exerts bacterio-static action against Gram-positive bacteria (Zaimiss, *Nature, Lond.*, 1961, **192,** 521 ; *Chem. Abstr.*, 1965, **63,** 8920, 1105 ; 1960, **54,** 9094 ; 1963, **58,** 14593 ; 1964, **60,** 6118, 12559 ; 1964, **61,** 15012 ; 1962, **57,** 11795 ; Draskoci & Jankovic, *Nature, Lond.*, 1964, **202,** 409).

Reserpine is added to poultry feed for growth promotion and feed efficiency ; a combination of traces of reserpine and manganese bacitracin, with or without procaine penicillin, is allowed in chicken and turkey feed in U.S.A. (*Chem. Abstr.*, 1966, **65,** 12771).

Other Alkaloids *Deserpidine* is almost as active as reserpine in its hypotensive and sedative activity. *Rescinnamine* is methyl trimethoxy cinnamoyl reser-pate. Quantitatively it is weaker than reserpine but qualitatively it has the same action ; it is reported to be less toxic than reserpine. The three alkaloids *ψ-reserpine*, *rescidine* and *raunescine* are also active although to a lesser extent than reserpine. In contrast to this group of alkaloids, *raugustine* and *isoraune-scine* are inactive (Schlittler in Manske, VII, 89, 91 ; Lewis, *J. Pharm., Lond.*, 1956, **8,** 465 ; Schlittler in CNS Drugs, 3, 5).

Reserpinine was reported to be devoid of any sedative or hypotensive effect ; in another investiga-tion, it was observed to possess a mild hypotensive activity (Lewis, loc. cit. ; *Chem. Abstr.*, 1957, **51,** 12326).

Serpentine is a yellow quaternary indolic anhydro-nium base. It produces hypotension and inhibits intestinal movements. Given with an equal amount of reserpine it was more hypotensive than either of the drugs in equivalent doses. It possesses anti-fibril-lar activity. Serpentine causes marked inhibition of

succinate dehydrogenase in brain and liver tissues. It produces a systemic and pulmonary hypotension due to a decrease in cardiac output ; there is no change in coronary flow, but coronary vascular resistance is decreased and myocardial oxygen consumption is unaffected. Serpentine is more toxic than ajmaline or serpentinine (Lewis, loc. cit. ; Dhawan & Bhargava, *Indian J. med. Res.*, 1959, **47,** 419 ; Arora & Madan, *Indian J. Pharm.*, 1956, **18,** 247 ; Bose & Vijayavargi, *Indian J. med. Sci.*, 1958, **12,** 440 ; *Chem. Abstr.*, 1965, **62,** 13739).

Serpentinine is a quaternary anhydronium base. It was found to raise the normal blood pressure, but in animals with experimental hypertension it caused a fall in blood pressure. Later workers have, however, concluded that it has a weak hypotensive activity. It stimulates the respiration and intestinal movements ; to the latter effect has been attributed its purgative action. Serpentinine diminishes the renal vasoconstriction activity of adrenaline but does not alter adrenaline hypertension (Chopra *et al.*, *Indian J. med. Res.*, 1942, **30,** 319 ; Deninger, *Pakist. J. sci. industr. Res.*, 1959, **2,** 114 ; Lewis, loc. cit.).

Sarpagine is a weakly basic, tertiary indolic alkaloid. It has only fleeting effects on blood pressure and the pressor amines (Schlittler in Manske, VIII, 811).

Ajmaline is the most abundant alkaloid of *R. serpentina.* It is a ditertiary indole base and has been synthesized. Ajmaline produces no sedation and like serpentinine its effect on blood pressure is in no way remarkable. The transient decrease of blood pressure appears to be due to its depressing effect on the cardiac tissues. Ajmaline has been reported to stimulate respiration and intestinal movements. The action of ajmaline on systemic and pulmonary blood pressure is similar to that of serpentine (Saxton in Manske, VII, 103 ; Schlittler in Manske, VIII, 811 ; Musamune *et al.*, *J. Amer. chem. Soc.*, 1967, **89,** 2506 ; Chatterjee & De, *Bull. Calcutta Sch. trop. Med.*, 1962, **10,** 15 ; Chatterjee *et al.*, *Bull. nat. Inst. Sci. India*, No. 4, 1955, 32 ; Mukerji in Chen & Mukerji, 79–85 ; *Chem. Abstr.*, 1965, **62,** 13739).

Ajmaline possesses anti-fibrillar activity, and its mode of action appears to be identical to that of quinidine. It is effective against extra systoles and exhibits useful adjunctive action in auricular fibrillation and a few other heart conditions, but it is not likely to displace quinidine or procaine amide for general use in cardiac arrhythmias. However, the use of ajmaline is indicated in the therapy of secondary arrythmias by excessive dosage of digitalis. Ajmaline may be useful in combination with antihypertensive agents for the treatment of hypertension complicated by a cardiac condition (*Chem. Abstr.*, 1962, **56,** 5336 ; 1963, **58,** 2768 ; 1966, **65,** 4461 ; 1962, **57,** 1501).

Isoajmaline produces hypotension and also causes drowsiness without sleep or loss of consciousness. *Ajmalicine* is a stereoisomer of tetrahydroalstonine. It possesses a central depressant activity in addition to its adrenergic blocking activity. *Ajmalinine* causes hypotension with renal vasodilation. It is sympatholytic (Bhatia & Kapur, *Indian J. med. Res.*, 1944, **32,** 177 ; Pakrashi, *Ann. Biochem.*, 1961, **21,** 367 ; Schlittler in Manske, VIII, 166 ; *Chem. Abstr.*, 1957, **51,** 12326 ; Lewis, loc. cit.).

Rauwolfinine has hypertensive properties. *Raujemidine* exhibits about one-half of the tranquillizing activity of reserpine. *Chandrine* possesses antiarrhythmic activity (Chatterjee & Bose, *Sci. & Cult.*, 1951–52, **17,** 139 ; Schlittler in Manske, VIII, 300 ; *Chem. Abstr.*, 1963, **58,** 846).

α-Yohimbine (rauwolscine) causes hypotension. It is reported to be a cardiovascular depressant with hypnotic activity and a relatively high toxicity (Chakravarti, *Sci. & Cult.*, 1941–42, **7,** 458 ; Mukherjee, ibid., 1952–53, **18,** 338).

Total alkaloids and extracts—The total alkaloids and extracts of *R. serpentina* roots have been found to exhibit a variety of effects such as sedation, hypotension, bradycardia, myosis, ptosis, tremors, relaxation of nictating membranes and diarrhoea, almost all of which are typical of reserpine. Extensive pharmacological and clinical comparison between reserpine and reserpine-containing alkaloidal fractions of rauvolfia indicated that the hypotensive and sedative actions of the latter could not be explained by the reserpine content alone ; active principles other than reserpine are said to contribute to the total activity of the drug. Hypotension caused by the total alkaloids was not thought to result from small amount of reserpine present since the onset of hypotension was speedy and of long duration. Further, the total alkaloidal fraction of the crude drug has been reported to be more potent in its tranquilizing effect than reserpine alone. However, there are also reports to the contrary : experiments using mouse ptosis and isotope dilution assays of whole roots have demonstrated that all of the biological activity could be accounted for by the reserpine content alone (Woodson *et al.*, 111–12 ; Saxton in Manske, VII, 91 ; Mukerji in Chen & Mukerji, 83–84 ; Burger, 563–64).

The total alkaloids, freed of reserpine, showed an accelerating action on the autolysis of rat brain and liver tissue, but to a lesser extent than reserpine. In contrast to reserpine, the total extract of *R. serpentina* inhibited the acetylcholine-induced contraction of the enervated dorsal leech muscle. The whole crude drug is reported to contain some principles which bring about undesirable side effects such as purgation and sexual debility (Rao, *Indian J. med. Res.*, 1960, **48,** 610; *Chem. Abstr.*, 1959, **53,** 491; Mukerji in Chen & Mukerji, 83-84).

Considerable variation in potencies of the extracts and total alkaloids of rauvolfia obtained from different sources has been observed. Studies on the total alkaloidal fractions of the roots from Bengal, Bihar and Dehra Dun showed that the Bengal type had the greatest hypnotic activity and the Dehra Dun type the least. Among the rauvolfia types examined for the hypotensive activity, the Dehra Dun and Terai (Himalayas) types were observed to be the most potent and the Malabar types the least active; the Bihar and Bengal (coastal plain) types were nearly of equal potency and about one-half as active as those from Dehra Dun. The crude resin from the roots possesses hypnotic activity, the alcohol fraction of the resin being the most active; freed of alkaloidal material (reserpine), the resin was completely inactive [Mukerji, *J. sci. industr. Res.*, 1955, **14A**(7), suppl., 1; Gupta & Kahali, *Indian J. med. Res.*, 1943, **31,** 215; Gupta *et al.*, ibid., 1944, **32,** 183; Ally, *Medicus, Karachi*, 1954, **9**(2), 37].

Four alkaloidal complexes, viz. serpajmaline, ajmalexine, resajmaline and a cream coloured powder, have been separated from the fresh roots of *R. serpentina* (Table 9). The complexes are said to be a convenient source material for the isolation of individual alkaloids; the major part of the total alkaloids in roots appears to occur in the form of complexes rather than as simple salts or free bases. The serpajmaline fraction is claimed to be free from reserpine and to be much more potent in its hypotensive activity than reserpine, without the sedative and central nervous system-depressant action of the latter. The antiarrhythmic effect of serpajmaline is greater than that of ajmaline, and the combination of serpajmaline and ajmaline (80:20) has the maximum effect. The effects of serpajmaline are attributed to the mutually potentiating synergistic action of its alkaloidal and non-alkaloidal constituents. However, another investigation of serpajmaline fraction demonstrated that the type of antihypertensive activity

TABLE 9—ALKALOIDAL COMPLEXES OBTAINED FROM FRESH ROOTS OF R. SERPENTINA*

Complex	Form	Yield, % (dry basis)	Constituents
Serpajmaline[a]	Light cream coloured powder	1.3-1.6	Ajmaline, serpentine, serpentinine, and two unknown substances, one probably reserpiline
Ajmalexine	do.	0.2-0.3	Mainly ajmaline and weaker bases including reserpine (5.5%), and rescinnamine (2.5%)
Resajmaline	Greenish viscous liquid	0.5-0.8	Mainly fatty matter, serposterol and other unsaponifiables, reserpine (2.3%), rescinnamine (0.5%), some weaker bases and traces of ajmaline
..	Cream coloured powder	..	Stronger bases and two unknown substances

* Siddiqui, *Chem. & Ind.*, 1957, 1270; *Pakist. J. sci. industr. Res.*, 1958, **1,** 3; Siddiqui *et al.*, ibid., 1959, **2,** 80.

[a] Serpentinine, ajmaline and tetraphyllicine were obtained from this fraction by another investigator (Schlittler in Manske, VIII, 294).

observed, closely resembles that of serpentine and serpentinine (Siddiqui, *Chem. & Ind.*, 1957, 1270; *Pakist. J. sci. industr. Res.*, 1958, **1,** 3; Siddiqui *et al.*, ibid., 1959, **2,** 80; Deininger, ibid., 1959, **2,** 93; Arora *et al.*, *Indian J. med. Res.*, 1967, **55,** 389; Schlittler in Manske, VIII, 294).

RAUVOLFIA PREPARATIONS

A large number of rauvolfia preparations are available in the market, and are sold under various trade names. The Indian products consist of powdered crude drug, and its liquid extract, dried extract, alcoholic tincture, and total alkaloidal fractions. The foreign pharmaceutical concerns, in addition, manufacture pure reserpine in several dosage forms such as tablets, elixir and injection. Injectible rauvolfia alkaloid solutions, stabilized by the addition of methionine and thiourea, and mixed preparations containing a rauvolfia ingredient together with some other active material are also marketed. Mention may be made of the alseroxylon fraction which is reported to be a selective fraction of rauvolfia from which the sympatholytic and hypertensive alkaloids have been removed and which retains only the antihypertensive, bradycardic and sedative activity. Rauvolfia preparations should be stored away from light in air-tight containers [Mukerji, *J. sci. industr. Res.*, 1955, **14A**(7), suppl., 1; Martindale, I, 739, 745-46; *Chem. Abstr.*, 1965, **62,** 8951; B.P.C., 1963, 705].

COMPOSITION OF SEEDS

The seeds of *R. serpentina* also contain rauvolfia alkaloids. Of the fresh seeds, those which are heavier than water (10–15% of the total seeds) contain 0.20–0.30 per cent alkaloids and the rest 0.13–0.14 per cent. The proximate composition of the seeds is as follows: moisture, 5.5–8.7; fat, 1.0–9.7; reducing sugars, 0.1–2.0; starch, 12.6–20.3; crude fibre, 56.5–75.5; nitrogen, 0.55–1.60; ash, 0.9–1.9; phosphorus, 0.07–0.22; and calcium, 0.34–0.69%. The protein of the seeds is largely made up of globulins. Generally, the seeds with high nitrogen and fat contents are reported to germinate well (Bajpai & Sharma, *Indian J. Pharm.*, 1956, **18,** 199; Dutta, ibid., 1962, **24,** 61; Nath & Rao, ibid., 1962, **24,** 187).

R. tetraphylla Linn. syn. *R. canescens* Linn.; *R. heterophylla* Roem. & Schult.

Sulochana, *J. Indian bot. Soc.*, 1959, **38,** 586, Fig. 4.

HINDI *Barachandrika.*

A small, much-branched woody shrub, 0.6–1.2 m. high, native of West Indies, introduced into India and found as a common weed in the vicinity of port towns along the coast line. It has spread inland and is found as an escape from cultivation in Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, West Bengal, Andhra Pradesh, Mysore, Madras and Kerala. Leaves whorled, elliptic; flowers greenish white or creamy white in umbellate cymes; drupes ovoid, deep purple when ripe; pyrenes rugose, oblong.

The plant is somewhat similar in habit to *R. serpentina* and is more hardy than the latter. It is reported to occur in most of the moist and hotter parts of India. It prefers sunlight. Experimental cultivation of this plant has been taken up in the lower hill ranges of Rongo (West Bengal). It can easily be propagated by seeds. It can also be propagated from hardwood cuttings after treating them with 30 p.p.m. of β-indolyl acetic acid for 12 hours. The survival rate of treated cuttings is reported to be 86 per cent whereas without the treatment, it is almost zero. Encouraging results have also been obtained by treating root- and shoot-cuttings with Seradix B, No. 3 (β-indole butyric acid) (Rajkhowa, *Indian For.*, 1967, **93,** 149; Kapoor & Gupta, ibid., 1966, **92,** 137; Chandra, *J. sci. industr. Res.*, 1956, **15A,** 125; *Sci. & Cult.*, 1956–57, **22,** 101; Biswas, *Indian J. Pharm.*, 1956, **18,** 227).

The root of *R. tetraphylla* occurs in straight, cylindrical, curved or conical segments, up to 12 cm. in length and 0.4–2.5 cm. in diameter. Externally it is greyish brown, brown to dark grey, or reddish brown where abraded, longitudinally wrinkled, some segments showing circular scars or stubs of rootlets, others bearing the crown with attached stem bases. The bark is readily peeled from the wood in many segments. The fracture of thin pieces is short and irregular and that of thicker pieces of sufficient length is irregular and splintery. The fractured surface exhibits light brown bark and pale yellow wood. The odour is indistinct and the taste very bitter (Woodson *et al.*, 36).

The roots of *R. tetraphylla* are often used as substitute or adulterant of those of *R. serpentina.* They contain the alkaloids listed in Table 7. At present, the roots are used for the commercial extraction of reserpine; however, according to one pharmaceutical firm, the reserpine content of the dried root is comparatively low (0.03–0.05%) (*Chem. Engng News*, 1955, **33,** 1074).

The major alkaloid of *R. tetraphylla* is α-yohimbine (rauwolscine) which is present in the root bark (0.1%), stem bark (0.2%), and leaves (0.5%). The leaves also yield aricine, reserpiline and *iso*reserpinine. The total alkaloid content (dry basis) of the leaves (0.4–1.2%), stems (0.10–0.29%) and roots (0.06–0.2%) varies with season, the maximum concentration being recorded during October–January. In a recent investigation, the leaves were reported to contain 1.8 per cent and the stems 0.5 per cent of total alkaloids. Serposterol (m.p. 152–54°), an antirheumatic substance, has been isolated from the roots [Woodson *et al.*, 54; Mookerjee, *J. Indian chem. Soc.*, 1941, **18,** 33; Stoll & Hofmann, *J. Amer. chem. Soc.*, 1955, **77,** 820; Mukerji, *J. sci. industr. Res.*, 1955, **14A**(7), suppl., 12; Rajkhowa, *Indian For.*, 1967, **93,** 149; Ghosh, Indian Pat., No. 63544, 1959].

The plant is reported to be poisonous. The poisoning effect includes pain in the mouth, constriction of the pharynx, burning sensation in the stomach and intestines, vomiting, dyspnoea, haemorrhagic diarrhoea, weak but quickened and irregular pulse, intense thirst and dysuria and finally death preceded by convulsions and coldness of extremities. An extract of the plant mixed with castor oil to form a liniment is prescribed for some kinds of chronic and refractory skin ailments. A decoction of the bark is employed in some parts of West Indies as an external application for chronic cutaneous diseases and to destroy parasites. The fruit causes violent and usually fatal alimentary inflammation. The dark juice of the fruit furnishes a black dye (Feuell, *Colon. Pl. Anim. Prod.*, 1955, **5,** 1).

About a dozen other species of *Rauvolfia* have so far been investigated chemically and a number of alkaloids isolated from them. No therapeutic use of these species has been made in regular medical practice. As reserpine is reported to be present in a number of species, it is likely that they may in future form the basis of various preparations now made from *R. serpentina*. Indian species of *Rauvolfia* are at present used mainly as adulterants of *R. serpentina* and include the following: *R. beddomei* Hook. f. is a shrub 150–80 cm. high, with oblanceolate leaves, pinkish white flowers, gibbously ovate drupes and rugose pyrenes, found in western ghats, Tirunelveli hills and Kerala; *R. densiflora* Benth. ex Hook. f. syn. *R. decurva* Hook. f. (ASSAM—*Dieng-la-tyrking, ding-soh-bubleng, diang-la-tyrkai, dieng-lar-kei*) is a large shrub 3–6 m. (occasionally 9 m.) high, with obovate or oblanceolate leaves, rose-red or white flowers, obliquely ellipsoid, brownish or purple drupes and rugose, compressed pyrenes pointed at the tip, found in the Himalayas, Khasi and Aka hills, and the western and the eastern ghats; *R. micrantha* Hook. f. (MALABAR RAUVOLFIA) is a slender shrub with elliptic-lanceolate or oblanceolate leaves, white flowers, obliquely ovate drupes and slightly rugose pyrenes slightly compressed in the upper half, found in Kerala up to an altitude of 300 m. (Sulochana, *J. Indian bot. Soc.*, 1959, **38,** 575; Youngken, *J. Amer. pharm. Ass., sci. Edn*, 1954, **43,** 141; Trease & Evans, *Pharm. J.*, 1954, **172,** 351; Atal & Schwarting, *Amer. J. Pharm.*, 1956, **128,** 365; Woodson *et al.*, 42, 45, 48).

The roots of *R. beddomei* contain ajamalicine, sarpagine and serpentine, but no reserpine. Samples of the roots of *R. densiflora* collected in the vicinity of Mahabaleshwar (Maharashtra) yielded 0.51 per cent of total alkaloids (reserpine, 0.01%). In addition to alkaloids, the isolation of a base, densiflorine (m.p. 71–73°), has been reported. In the roots of *R. micrantha*, in addition to reserpine, six other alkaloids have been identified. The alkaloids present in the roots of the above mentioned species are listed in Table 7 (Bose *et al.*, *J. Indian chem. Soc.*, 1956, **33,** 379; Rajagopalan, *J. sci. industr. Res.*, 1954, **13B,** 77; Purohit & Majumdar, *J. Instn Chem. India*, 1963, **35,** 131; Rao & Rao, *Indian J. Pharm.*, 1956, **18,** 202).

RAVENALA Adans. (*Musaceae*)

A genus of two species of tree-like herbs, native of Malagasy and S. America. One species is cultivated in India as an ornamental.

R. madagascariensis Sonn. TRAVELLERS' PALM

Fl. Br. Ind., VI, 198; Benthall, 427, Fig.

BENG.—*Panthopadop*.

A striking, elegant, palm-like tree with a fan-shaped crown, native of Malagasy and found cultivated in Indian gardens. Pseudostem woody, reaching up to 30 m. in height, though in India it grows to only 6–12 m. Leaves distichous, large, 2–3 m. long, and 1.0–1.5 m. broad, spreading out fan-wise; flowers in compact clusters, each flower enclosed in a bract; fruit a capsule; seeds surrounded by a mass of bright blue or purple arils.

The plant thrives in low, warm and humid areas up to 450 m. near the coast and grows best in a sheltered position. It can be propagated either by suckers or seeds (Gopalaswamiengar, 246).

In Malagasy the wood of the trunk is used for house construction. Sugar is extracted from the sap. Leaves are useful as packing material and for roofing. The midribs and stalks are used for hut walls (Burkill, II, 1886; Uphof, 307; Neal, 204; Fl. Egypt, III, 525).

Rain-water collected at the base of the leaf blades is said to be used for drinking, although it is often rendered undrinkable by infestation with mosquito larvae, etc. (Firminger, 343; Gopalaswamiengar, 246).

The mealy seeds are edible. The bright bluish arils enclosing the seeds are tasteless and yield (57.1%) a semi-solid, almost colourless fat having the following characteristics: m.p. 35–40°, acid val., 15.8; iod. val., 61.2; and sap. val., 185.6. The fat is used for cooking; it is also reported to be antiseptic (Fl. Egypt, III, 525; Neal, 204; *Chem. Abstr.*, 1948, **42,** 4238; Burkill, II, 1887).

Realgar — *see* **Arsenic Ores**

Red Bark — *see* **Cinchona**

Red Cedar — *see* **Cedrela, Erythroxylum, Juniperus**

Red Dhup — *see* **Parishia**

Red Pear, Indian — *see* **Protium**

Red Wood — *see* **Adenanthera**

Red Wood, Andaman — *see* **Pterocarpus**

Red Wood, Indian — *see* **Soymida**

Reed, Common — *see* **Phragmites**

Reed, Great — *see* **Arundo**

Reed, Mace — *see* **Typha**

REICHARDIA Roth (*Compositae*)

Fl. Br. Ind., III, 413.

A small genus of perennial or glabrous milky herbs distributed in western Asia, Europe and North Africa. One species, *R. tingitana* (Linn.) Roth syn. *Picridium tingitanum* Desf., is found in Punjab and West Bengal. It is a small annual with stout stems, said to be relished by all stock in Sudan (Tothill, 685).

REIDIA Wight (*Euphorbiaceae*)

Fl. Br. Ind., V, 302.

A large genus of shrubs, extending from South India and Ceylon to Malaysia and the Philippines. About 12 species occur in India.

This genus is considered as a synonym of *Eriococcus* Hassk., which has been reduced to a subgeneric status and included under the genus *Phyllanthus* Linn. (Webster, *J. Arnold Arbor.*, 1957, **38,** 359).

R. ovalifolia Wight syn. *R. longiflora* Gamble; *Phyllanthus longiflorus* Heyne ex Hook. f. (Tam.—*Nallapulatti* ; Mal. -*Malenkizhanelli*) is a small bush with obliquely obovate-oblong leaves, pink flowers, and small capsular fruits (0.4 cm. long), distributed in the hills of Kerala and Tirunelveli up to an altitude of c. 600 m. The fruits are reported to be pickled (Rama Rao, 357).

Reindeer Moss — *see* **Lichens**

REINWARDTIA Dum. (*Linaceae*)

D.E.P., VI(1), 427 ; Fl. Br. Ind., I, 411 ; Kirt. & Basu, Pl. 164B.

A small genus of undershrubs distributed in India and China. One species is found in India.

**R. indica* Dum. syn. *R. tetragyna* Planch.: *R. trigyna* (Roxb.) Planch. (Hindi—*Basanthi* ; Punjab *Karkun, gud batal, basant* ; Kumaun—*Piunli* ; Bombay—*Abai* ; Mundari—*Gara sokoe, seta chakonda* ; Khasi—*Syntew-lang-ksir, tin-wa-lei*) is a tufted, glabrous undershrub, 60–120 cm. high, with elliptic-lanceolate or oblanceolate leaves, yellow flowers and globose capsules found in the Himalayas from Kashmir to Sikkim, up to 2,100 m., and in the upper Gangetic plain, Bihar, Orissa, Assam, western ghats, Deccan and Mt. Abu.

The plant is commonly grown in gardens for its showy bright yellow flowers ; it can also be used as a border plant. It is propagated by division of roots in October. The plant is closely allied to *Linum* and has been found to be resistant to all five races of rust in India (Firminger, 599 ; Rao, *Indian For.*, 1958, **84,** 270 ; *Annu. sci. Rep. Indian agric. Res. Inst.*, 1956, 90).

The plant is used in Bihar for the treatment of paralysis. It is used as a medicine for founder in cattle. The crushed leaves and stems are applied to wounds infested with maggots (Bressers, 22 ; Kirt. & Basu, I, 411).

REISSANTIA Halle (*Celastraceae ; Hippocrateaceae*)*

A small genus of lianas or sometimes shrubs, rarely small trees, distributed in the tropics of the Old World. Two or three species occur in India.

R. indica Halle syn. *Hippocratea indica* Willd. : *Pristimera indica* A. C. Smith

Fl. Br. Ind., I, 624 ; Fl. Malesiana, Ser. I, **6**(3), 401 ; Talbot, I, Fig. 169.

Beng.—*Atari-lata, kathapaharia* ; Mar. *Kazurati, tirruli* ; Tel.—*Verriyaapa* ; Tam.—*Odangod* ; Kan.—*Kangunabally*.

Cachar—*Sibrai-ia-dam* ; Nepal—*Phirke-lera*.

A liana or sometimes a shrub or a small tree, commonly found in the hotter parts of North-East India and peninsular India. Leaves variable in size and shape ; flowers fragrant, very small, rusty yellow or greenish yellow, in axillary and terminal compound cymes ; fruits oblong ; seeds winged.

The sap of the stem is taken as a febrifuge. The leaves contain an alkaloid ; they are scorched, seasoned and given to women during confinement. The root bark is used for the treatment of respiratory troubles ; an extract of it is given to ease constipation. The powdered roots and leaves are sometimes applied to sores and wounds [Fl. Malesiana, Ser. I, **6**(3), 402 ; Bhatnagar & Divekar, *J. sci. industr. Res.*, 1951, **10B,** 56 ; Wehmer, II, 724 ; Irvine, 1961, 454].

The roots contain dulcitol (yield, >1%). The root bark contains an antibiotic principle, pristimerin (0.1% ; $C_{30}H_{40}O_4$, m.p. 219–20°). It is concentrated mostly in the phellum and to a lesser extent in the inner red bark. Pristimerin shows considerable *in vitro* activity against several Gram-

* Some authors consider *R. trigyna* Planch. and *R. tetragyna* Planch. as varieties of one and the same species with many sexual forms, while others consider them distinct (Fl. Br. Ind., I, 411 ; Fl. Madras, 126 ; Hara, 168).

* According to Ding Hou, overwhelming evidence is in favour of accepting *Celastraceae* over *Hippocrateaceae* [Fl. Malesiana Ser. I, **6**(3), 230, 389].

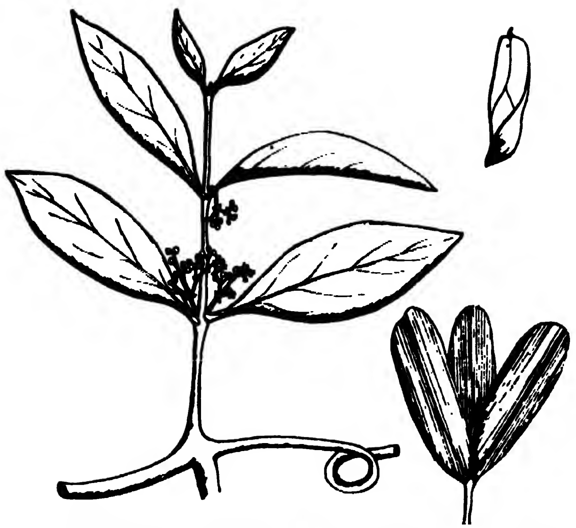


FIG. 142—REISSANTIA INDICA—FLOWERING BRANCH AND FRUITS

positive cocci, both haemolytic and non-haemolytic, particularly against *Streptococcus viridans*, the causal organism of tonsillitis and streptococcal arthritis, and *S. faecalis*, which is known to cause urinary complications. Clinical trials have shown that pristimerin is effective in the treatment of inflammatory conditions of the naso-pharyngeal mucosa, resulting from common colds and influenzal infections. It is useful as an adjunct to the common antibiotic therapy of respiratory inflammations of both bacterial and viral origin. Pristimerin also inhibits *in vitro* the growth of different strains of *Mycobacterium tuberculosis*, and is reported to possess anti-tumour properties, but its high toxicity precludes its use as a cancero-static agent (Bhatnagar & Divekar, *J. sci. industr. Res.*, 1951, **10B**, 56 ; Kamat *et al.*, ibid., 1955, **14C**, 1 ; Chopra & Chopra, ibid., 1959, **18C**, 85 ; Bhatnagar *et al.*, Indian Pat., No. 40968-40970, 1949 ; Dictionary of Organic Compounds, I. 575-76 ; Nakanishi *et al.*, *J. org. Chem.*, 1965, **30**, 1729).

R. grahamii (Wight) Ding Hou syn. *Hippocratea grahamii* Wight ; *Pristimera grahamii* A. C. Smith (Mar. *Danshir, daushir, lokandi, yesti, zewati*) is a climbing shrub, with very variable leaves, white flowers in axillary cymes, linear-oblong fruits and ovoid-oblong winged seeds, mostly found in Konkan and North Kanara ; it also occurs in the Deccan plateau and in the South Andamans. The roots contain about twice the amount of pristimerin as in *R. indica* and show similar antibiotic properties. The seeds are reported edible (Information from Col. S. S. Bhatnagar : Hedrick, 305).

Rejoua — *see* **Ervatamia**

REMIREA Aubl. (*Cyperaceae*)

Fl. Br. Ind., VI, 677.

A monotypic genus of sedges represented by *Remirea maritima* Aubl., found growing throughout the tropics. In India, it is found growing on the coastal sandy regions almost within tidal limits in west coast, in North and South Kanara and Malabar districts. The rhizomes sometimes grow several metres long, rooting at the nodes and producing erect stems up to 15 cm. high. The leaves are rigid, linear, 2.7-7.5 cm. long and pungent.

The plant is reported to be an effective sand binder. The root is aromatic and an infusion of it is said to be used in Brazil and Guiana as a sudorific and diuretic. The rhizome is astringent and diuretic (Dalziel, 519 ; Burkill, II, 1888 ; Chopra, Nayar & Chopra, 211 ; Cains, *J. Bombay nat. Hist. Soc.*, 1935-36, **15**, 33).

REMUSATIA Schott (*Araceae*)

A small genus of herbs, native of India and Java and distributed in the tropics of Asia and Africa. Two species occur in India.

R. vivipara Schott

Fl. Br. Ind., VI, 521.

Mar. *Rukhalu*.

A tuberous herb, sometimes epiphytic, found nearly throughout India in the sub-tropical Himalayas at 600-900 m. altitude, from Kumaun to Sikkim, in the Khasi hills, Bihar, Maharashtra, Mysore, and the western ghats. Tubers 2.5-3.75 cm. in diam. ; shoots 15-30 cm. long, simple or shortly branched, bearing at the nodes clusters of oblong scaly bulbils ; leaves peltate, large, 10 to 45 cm. diam., membranous, orbicular-ovate, acute or acuminate ; spathe 10.0-12.5 cm. long, coriaceous ; spadix 2.5-3.75 cm. long.

The leaves are used as vegetable. The tubers are edible, but require careful boiling to rid them of irritating crystals. The aromatic root, made into an ointment with turmeric, is used as a remedy for itch. The juice is considered alexipharmic (Santapau, *Rec. bot. Surv. India*, 1953, **16**, 332 ; Chopra, Nayar & Chopra, 211 ; Kirt. & Basu, IV, 2612).

Rennet, Cheese — *see* **Galium**

Rennet, Indian — *see* **Withania**

RESEDA Linn. (*Resedaceae*)

A genus of annual or perennial herbs distributed in the Mediterranean region, East Africa and West Asia. Two species are introduced into India and grown in gardens.

R. luteola Linn. DYER'S ROCKET, WELD

D.E.P., VI(1), 436; Fl. Br. Ind., I, 181; Butcher, I, 353, Fig. 240.

A biennial glabrous herb, 50–150 cm. high, indigenous to western Europe and grown in gardens in India, but also found as an escape from cultivation. Rosette leaves narrowly oblanceolate, sessile, stem leaves narrowly oblong; flowers yellowish green, in terminal spike-like racemes; capsules ovoid to subglobular, divided nearly half-way into 3 acuminate lobes.

The plant was formerly grown as a source of an excellent deep yellow dye used for colouring silk and wool. Luteolin is the main colouring principle and is accompanied by apigenin. It is distributed in all parts of the plant, but the maximum concentration occurs in the upper extremity and the seeds. A luteolin glucoside named luteoloside has been isolated from the fresh blossoms and other parts of the plant. It has a low toxicity and a mild influence on capillary resistance and possesses diuretic properties [Hill, 130; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 36; Perkin & Everest, 153; *Chem. Abstr.*, 1956, **50**, 2925; 1962, **56**, 13251].

The leaf, stem, root and seed contain a mustard oil. A recent examination has shown the presence of an *iso*thiocyanate glucoside, glucobarbarin, in the leaf, inflorescence and seed. On enzymic hydrolysis, the glucoside yields (*l*)-5-phenyl-2-oxazolidine thione. The seeds yield 30 per cent of a fatty oil. D-(3-Carboxy-4-hydroxyphenyl)-glycine, DL-(3-carboxyphenyl)-glycine, L-(3-carboxyphenyl)-alanine, and L-(3-carboxy-4-hydroxyphenyl)-alanine have been isolated from the seed extract (Kjaer & Gmelin, *Acta chem. scand.*, 1958, **12**, 1693; Kjaer & Larsen, ibid., 1963, **17**, 2397; Wehmer, I, 417).

All parts of the plant are considered diuretic, diaphoretic and anthelmintic. In New South Wales, it is reported to be poisonous to sheep (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 138).

R. odorata Linn. MIGNONETTE

D.E.P., VI(1), 436; Fl. Br. Ind., I, 181; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 36, Fig. 9.

An annual, 15–60 cm. high, indigenous to North Africa and cultivated in gardens in India. Leaves spathulate or oblanceolate to elliptic-oblong; flowers very fragrant, varying from yellowish white to orange and red in cultivation, in spicate racemes; capsules obovate-globose, torulose.

Mignonette is grown for its fragrant flowers produced during the cold season. It is excellent for pots, beds and cutflowers and for growing near windows and in shrubbery. It has been greatly modified under domestication, and several varieties have been raised, the most important of which is the compact, strong-growing, red-flowered *Machet*, much grown in pots in Europe. It grows in almost any soil, but prefers a rich, fertile, clean soil, with plenty of sun and irrigation. It is propagated by seeds. The flowers attract bees when in full bloom [Bailey, 1947, III, 2918; II, 2049–50; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 36; Vishnu Swarup, 116; Howes, 1945, 168; Bakshi, *J. Bombay nat. Hist. Soc.*, 1954–55, **52**, 490].

The flowers are the source of an essential oil, Mignonette Oil, which on dilution exhibits the characteristic sweet odour of fresh blossoms. Because of the very low yield obtained by steam distillation, the flowers are extracted with petroleum ether whereby concretes and absolutes are obtained. Steam distillation of the absolute gives an essential oil (yield, 0.003%, based on the flowers) having a yellow colour and an intense mignonette odour. The oil congeals in the cold and has the following characteristics: sp. gr.$^{15°}$, 0.961; $[\alpha]_D$, +31.3°; acid val., 16.1; and ester val., 85. Eugenol, phenol, paraffins, free caprylic acid, higher fatty acids and acetic acid esters have been detected in an oil derived by co-distillation of mignonette concrete with diethylene glycol. Mignonette oil has been used in high grade perfumes of the French type (Guenther, V, 401; Naves & Mazuyer, 217; *Rep. essent. Oils Schimmel*, 1947–48, 38).

The fresh roots yield 0.035 per cent of an essential oil (sp. gr.$^{15°}$, 1.067; $[\alpha]_D$, + 1.5°) possessing a radish-like odour, and consisting largely of β-phenylethyl *iso*thiocyanate. The seeds contain 40 per cent of a fatty oil and a small amount of methyl *iso*thiocyanate (Finnemore, 345; Kjaer *et al., Acta chem. scand.*, 1953, **7**, 1276).

The herb is reported to allay irritation and ease pains. The root of the plant is acrid and is used in Spain as a laxative, diaphoretic and diuretic. The seeds are applied externally as a resolvent (Steinmetz, II, 378; Kirt. & Basu, I, 203).

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(Names in Indian Languages, Regional and Trade Names and Common English Names)

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